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ILLINOIS TECHNOGRAPH

APRIL, 1957

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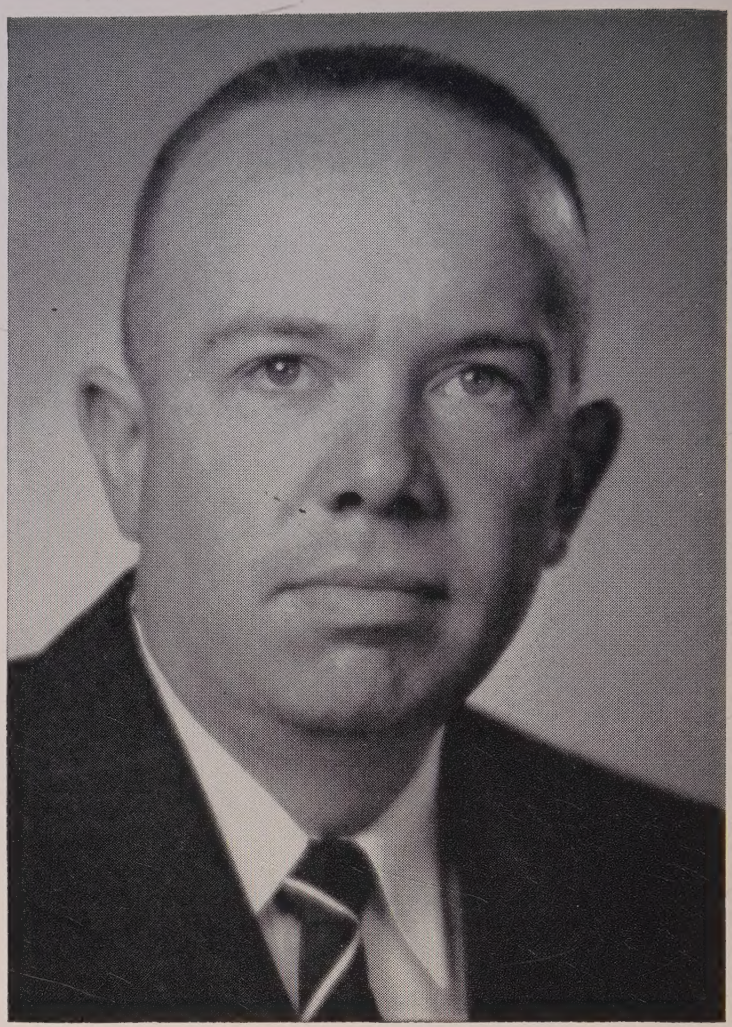
Kenneth A. Brown, class of '46,
speaks from experience when he says:

"There's plenty of chance for advancement at U. S. Steel for the man who really wants to get ahead."



IF KENNETH A. BROWN were to speak to you face to face, he would tell you: "Hi fellows . . . I'm not much older than you . . . I still like a lot of the same things you do. In addition, I like my work and I sincerely believe that you will like your work at United States Steel, and like the fine bunch of fellows with whom you will come in contact."

Mr. Brown, at the comparatively young age of 29, is presently Works Engineer in charge of all engineering for the Worcester Works of the American Steel & Wire Division. He graduated from Brown University in 1946 with a B.S. degree in Engineering. He first joined U. S. Steel as a Junior Engineer at the Worcester Works, Worcester, Mass. Although his original duties included much drafting, he acquired a general administrative background and engineering experience. This qualified him for promotion to Assistant to the Works Engineer in May, 1950. Despite a tour of military service for two years, Mr. Brown's development resulted in his being transferred to the Construction Division in the Cleveland General Office. Starting January 1, 1953, he worked out of this office as Chief of Party on various construction projects.

On June 1, 1955, Mr. Brown returned to engineering and maintenance assignments at the Duluth Works. Although his work was primarily concerned with engineering problems, he also acquired a knowledge of various phases of maintenance. This experience qualified him for promotion to the position of Division Engineer on April 1, 1956. On January 1, 1957, Mr. Brown returned to the Worcester Works in his present capacity of Works Engineer.

Mr. Brown's "success story" is typical of that of many graduate engineers who have associated themselves with U. S. Steel. "The unlimited opportunities at U. S. Steel," says Mr. Brown, "plus the fine and helpful spirit that exists among the personnel, make success a matter of one's willingness to work to learn and to fit into the friendly atmosphere which exists here."

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THE ILLINOIS TECHNOGRAPH

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Cover . . .

Never satisfied with things as they are, the research scientist takes apart the raw materials of nature to capture the basic "building blocks" of the universe. Our cover this month is "Unlocking the Secrets of the Universe," by Union Carbide and Carbon Corp.

General Motors wants Good Men

THIS IS ABOUT the time of year when engineering seniors sit down to some serious thinking about their futures.

For now is the time when they must start to decide which company they would like to join.

And now is the time when they must begin taking definite steps toward joining it.

SO IF YOU'RE among those mulling over that problem—here is some interesting news for you:

General Motors is seeking outstanding engineering graduates in a wide variety of technical fields.

- GM offers you the untold advantages of its nearly boundless facilities and resources—including the fabulous new GM Technical Center.
- Training programs to help you grow professionally.
- Increasing responsibilities to match your growing talents.
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- The chance to work closely with some of America's finest engineering minds in one of GM's 34 decentralized manufacturing divisions, 126 plants in 68 cities.
- Most especially, GM offers you the creative climate of a corporation dedicated to what GM President Harlow H. Curtice recently called, "The inquiring mind."

IF YOU FEEL these advantages can do for you what they've done for thousands of engineers who have carved richly rewarding careers with GM—now is the time to take steps.

If you believe that you have a great deal to offer General Motors in return—now is the time to let us know.

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GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

What'll it be?

We see where a noted firm of architects which designed the United Nations center in New York has been asked to submit plans for the University's proposed Auditorium-Fieldhouse, or whatever its official title is to be.

This is fine. Such a project is rather difficult to conceive, since it would combine features for athletic events such as Big Ten basketball games and the State High School Tournaments as well as events of a cultural level, such as Star Course, and perhaps theatrical presentations and ballet.

The trouble is that everybody seems to be asking too much of the proposed building. The athletic department is crying for a fieldhouse. With Huff Gym being as small as it is, and interest in basketball being what it is, this is a definite need.

The Music department and various other groups are demanding space to make up for what our cherished Auditorium lacks. They want a place to have full-stage productions such as symphony orchestras, ballet performances and other events which have been housed, rather ineptly, in Huff Gym and the Auditorium.

A project involving all these needs is quite serious and we are glad to see architects of the stature of those called in. Yet, what about home-grown talent. Don't our Art or Architecture departments have any schemes to incorporate these needs? Isn't there anyone on campus who can design structures with more imagination than found on the clean, functional, dull lines of MRH or the new LARH addition?

If we want to incorporate desirable features into the new structure and keep it from being a campus version of Madison Square Garden, let's get everybody's idea and let's also keep every factor in mind.

The athletic department stands most to gain by this project and may have the most influence, but let's not let their influence predominate at the expense of everyone else.

MORROW PLOTS—

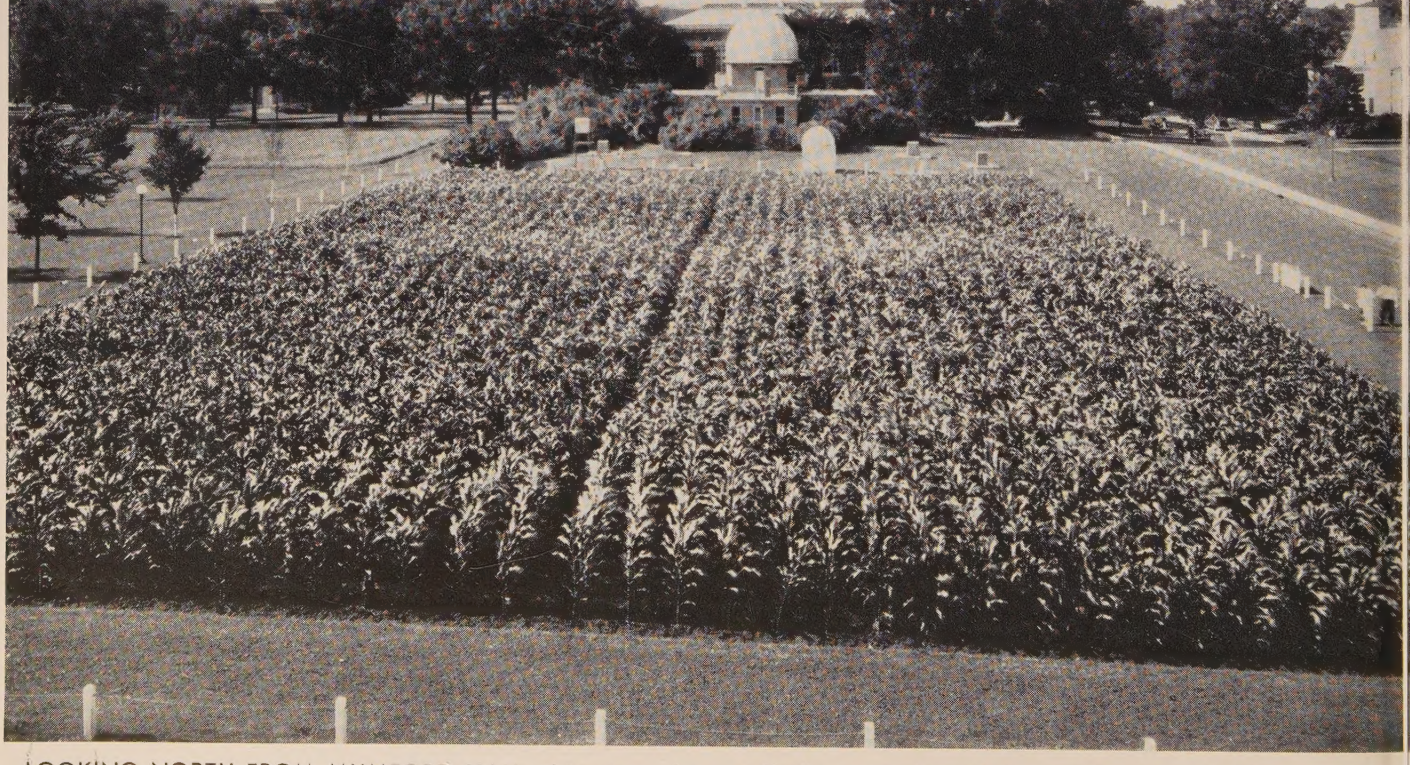
Where the Tall Corn Grows

by John Brennan, Ag. E. '59

Impressively gracing South Campus, this world-famous cornfield has led to many outstanding advances in the field of Ag Engineering.

Making every acre one third larger is a pretty good engineering feat. But, the Morrow Plots have shown us just how to do that very thing.

The Morrow Plots are the oldest experimental plots in the United States and they contain the oldest continuous corn plot in the world. They have supplied much information about the effects of land use practices on the soil. The Morrow Plots, as Prof. George E. Morrow established them in 1876, consisted of ten half-acre plots. In order



LOOKING NORTH FROM MUMFORD HALL, this view shows all that remains of the original ten half-acre plots founded by Prof. Morrow. The tall corn in the foreground has received soil-building applications, while that in rear has received little treatment since 1876.

CORN YIELDS

Cropping System	Treatment	Acre Yield (bu.) 1955	Acre Yield (bu.) Av. for 12 year perior
Continuous corn	Untreated	36	22
	1955 treatment only	86	
Continuous corn	MLP[1]	79	64
	1955 treatment and MLP[1]	98	
Corn, oats	Untreated	43	36
	1955 treatment only	97	
Corn, oats (catch legume)[2]	MLP[1]	98	100
	MLP[1] and 1955 treatment	107	
Corn, oats, legume	Untreated	63	68
	1955 treatment only	102	
Corn, oats, legume	MLP[1]	100	109
	MLP[1] and 1955 treatment	101	

[1] Indicated plots on which manure, lime and phosphate have been applied as needed since 1904.

[2] After the oats have been harvested legumes are seeded and are plowed under prior to seeding of corn the following year.

to make room for the ever growing University of Illinois, seven of them have been discontinued. The other three, slightly reduced in size, are still in use. They are Plot 3, cropped to continuous corn, Plot 4, cropped to a corn-oats rotatin, and Plot 5, cropped to a corn-oaats-clover rotation.

The plots were established to settle a heated controversy about whether the deep, rich Illinois soils could ever be depleted. From 1876 to 1904 the plots were cropped without the addition of any fertilizers to study the effects of this type of soil management on soil depletion. By 1904 the evidence of soil depletion became pronounced. The same soil which produced 54.3 bushels of corn per acre in 1889 yielded only 21.5 bushels of corn per acre in 1904.

Then the question arose, "Can the depleted prairie soils of Illinois be rebuilt to their original level or higher?" In 1904 each plot was divided into a north and a south half to study the effects of a system of fertilization involving the use of manure, limestone and phosphate. This fertilizer was applied to the south half of each plot in quantities beyond that thought adequate to meet the needs of the crops to be grown.

During the next fifty years the yields under the cropping systems were compared on both the fertilized and unfertilized portions of the original plots. Large differences in yield between the treated and untreated plots, and among three cropping systems, continuous corn, corn-oats and corn-oats-clover rotations, developed during these fifty years. In 1910, only six years after the first application of MLP, the treated continuous corn plots produced 54.6 bushels of corn per acre. This was equal to the amount of corn produced per acre on this same land in 1889. The first lessons on stretching an acre through increased crop yields had been learned.

Laboratory studies of soil samples collected from the Morrow Plots have shown that the organic matter and aggregate stability of the surface soil have been reduced materially on the plots cropped continuously to corn as compared with those in the three year rotation. Such differences in the physical properties of the soils seemed to be correlated with the corn yields. Thus the question arose as to whether the yield differences due to the past management were a result of the physical condition of the soil or whether they were primarily due to nutrient deficiencies which could be remedied by the application of sufficient quantities of plant food.

The plots and cropping were such that all plots were in corn every six years. That sequence occurred in 1955 and gave an opportunity to apply commercial fertilizers to a portion of each plot and to compare the overlal resulting yields. This was the first major change in the cropping program in over fifty years.

The chart shows effects of commercial plant foods as well as MLP and rotation on corn yields.

The data indicates that the yield differences associated with management practices were largely removed with the application of liberal amounts of commercial plant food. The extra nutrients did not, however, result in heavier yields on plots which had previously received good management practices. Or in other words, depleted soils may be made to produce larger crops with the application of the correct plant foods. However, commercial fertilizers alone will not give maximum yields. Application of plant nutrients to already rich soil will not significantly increase the yields, therefore, such applications are a waste of money.

The two most important lessons learned from the Morrow Plots are:

1. Soils can be exploited and depleted.

2. Manure, lime, phosphate and commercial plant food can boost yields. But really to hold your soil fertility you need a simple rotation, too.

In 1956 the eighty-first crop was harvested from the Morrow Plots. The Morrow Plots have truly been called the most valuable field in America. Few farmers who have followed their teachings would disagree.

JOHN MORAN, who joined Western Electric's engineering staff at the Kearny Works recently, is now studying for his M.S.M.E. under the new Tuition Refund Plan. Western Electric expects to refund the tuition for John's graduate study at the Newark College of Engineering this year

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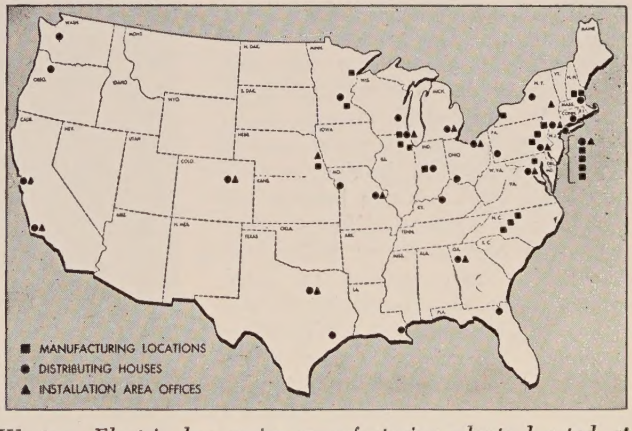

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Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Farmer or Engineer?

What is an Ag Engineer?

by Jim Allen, Ag. E. '57

Almost every Agricultural Engineer, upon stating his profession to a stranger, is called upon to explain his work. This is not at all surprising, since the Agricultural Engineering profession is relatively new and its members number only a few thousand. Yet, in spite of their few numbers, they are one of the more important professions in the world, for they serve the industry which supplies food and fiber for the world—Agriculture.

Basically, the Agricultural Engineer is an engineer concerned with applying engineering technology — calculus, the strength of materials, machine design and layout, etc.—to agricultural problems. They take the same basic courses in college that an E.E., M.E., or C.E. does—plus a few agricultural courses.

In some respects their job is more complex than that of the Mechanical or Electrical Engineers because they are confronted with a maze of variables (soils, plants, animals, and the weather) which combine to create engineering problems to which the application of basic scientific laws is often not easy. That they have succeeded in solving these problems is illustrated by some of their achievements. Consider the combine, for example. The average combine can be adapted to operate under soil conditions ranging from the mud of Louisiana rice fields to the dust of California wheat fields. It can harvest any one of several hundred different seeds ranging from oats to flower seeds. Now, thanks to our own Agricultural Engineering staff at the University of Illinois, the combine has been adapted to harvest corn. Several major farm implement companies recently began adapting their combines so they could harvest corn after the Illinois research proved that the change-over was practical. This may mean a savings of millions of dollars each year to the farmers, for it eliminates the need for corn pickers and shellers—two pieces of machinery which can cost a total of several thousand dollars.

Four Fields

Basically, Agricultural Engineering is concerned with four fields—Power and Machinery Design, Soil and Water Conservation, Building Design, and Farm Electrification. The most spectacular gains made by Agricultural Engineers have been in the field of Power and Machinery. Only 50 years ago, at the time of the birth of Ag. Eng. crops were raised and harvested almost exclusively with animal and human labor. The average Midwest farm had up to 20 horses and mules to feed and care for. Anyone who has had the task of harnessing just one horse will appreciate the task of harnessing 20 of them every day all spring and summer. Also, enormous crews of men with huge smoking, threshing rigs traveled from farm to farm all summer to harvest the small grains. Stock water, at least on the dry prairies of Central Illinois, was pumped by hand or by unreliable windmills. The production of one acre of corn required an average of 20 hours of work. Now, in contrast, an acre of corn can be produced by 10.3 hours of labor—or much less, if the farmer is above average. Now, if a new plow-plant method of

L. B. MILLER AND PROF. A. L. LAND inspect the 1956 corn yield from one of the Morrow Plots. It was treated with varying amounts of manure, lime, phosphate, nitrogen and potassium. Yield ranged from 29.4 to 128 bushels per acre. Another example of ag engineering.

corn production which eliminates most of the tillage and cultivation of corn comes into common usage, even this figure may be halved.

These figures illustrate only one of many of the remarkable reductions in labor requirements which Agricultural Engineers have brought about. The resultant increase in the amount of work each man can do has spurred on the continual increase in farm size and decrease in agricultural workers which is taking place. In many areas farms have increased up to 50% or more in size since the turn of the century—while the farm labor force has been reduced about 40%. The hired man of 50 years ago has gone to town to work.

The most spectacular machines designed by Agricultural Engineers have been the tractor, combine, and corn picker. The average tractor of today is an extremely versatile machine. Pulling a plow or combine, it can cover 15-20 acres a day—and with a modern disk or cultivator, it can work as much as 75 acres a day. The corn picker can easily pick 1,000 bushels of corn per day—and in the old days an average man could not average over 60 or 70 bushels a day. Indeed, it was, and in some backward areas still is, the ambition of many men to be able to pick 100 bushels a day by hand. Even the rare individual who can achieve this difficult task is doing only 1/10 as much as the modern corn picker.

Rural electrification promoted by Agricultural Engineers, has done much to improve the lot of the farmer. The average farm today has at least 5 or 6 fractional H. P. electric motors—each doing as much or more than a high priced 1/10 H. P. man can do. Some farmers today have installed completely automatic electric powered feeding systems which handle several tons of materials every day. Mechanical power, of course, is the only reasonable way to handle large quantities of materials—whether the materials are industrial goods or farm products makes no difference. The amazing thing is that many farmers have not yet installed such systems. They are still handling grain, hay, and silage with stone age methods. On some farms up to 80% of the farmer's time is spent around the farmstead doing these chores. This indicates that Agricultural Engineers still have the job of selling improved feed handling systems to all farmers.

Goals Achieved

This goal, considered a wild dream by some, is not as far away as it might seem. Only 25 years ago the goal of complete rural electrification was considered impossible by some—and now it has almost been achieved.

Agricultural Engineers are also concerned with the design of practical, labor saving, easily adaptable farm buildings. The average farm building has a life of at least four years. Since the average operator lives on a farm only 12 years, the average building is used for a multiplicity of purposes during its life. Yet, in the past, farm buildings have seldom been built so they could be readily converted to other uses. The ornate horse barns of Central Illinois are perhaps the best example of this. These large, drafty, expensive, and uversatile buildings would never be designed by a modern Agricultural Engineer. In general, the new farm buildings now coming from the drawing board are low, inexpensive, and highly versatile.

Soil Conservation

Still another important group of Agricultural Engineers are those who serve as soil conservation technicians. This trained group of men has the task of designing and installing the countless thousands of erosion control structures (drop boxes, weir notch dams, and other mechanical water control devices) needed to prevent the growth of gullies. They also design and supervise the construction of terraces, lakes, irrigation systems, drainage ditches, dams and even levees, and other earth and concrete structures.

At present, a large number of Ag. Engineers are employed by the USDA and the various colleges and universities. Many of them find jobs with large farm equipment companies. The supply of Ag. engineers is at present far exceeded by the demand, although a total of some 40 schools offer degrees in Ag. Engineering.

The parent organization of the Agricultural engineers is the American Society of Agricultural Engineers (ASAE which was founded in 1907 and now has grown to a total of 4,700 members in some 40 countries. The society's official journal—*Agricultural Engineering*—is published monthly by the national headquarters in St. Joseph, Mich.

All in all, Agriculture has advanced a great deal since the days when the country blacksmith and the local barn builder were the only designers of farm equipment and buildings. Agricultural Engineering has taken over the place of these old trades and, through the application of engineering principles to farm design problems, it has created in the United States an agricultural technology superior to any in the world.

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Breaking through...

THE SOUND BARRIER

Whitcomb's area rule furnishes a solution to the problem of approaching sonic velocity with its increase of drag rise.

by Fred Breuer, Aero. E. '57

The sharp drag rise which invariably accompanies an aircraft's approach to sonic velocity was the basis for the sound barrier which plagued aerodynamicists only recently. This drag increase created a seemingly, insurmountable obstacle to any aircraft which might otherwise have flown faster than sound.

A major breakthrough in the aeronautical sciences furnished a solution to this dilemma in 1952. Richard T. Whitcomb, working at NACA's Langley Aeronautical Laboratory, Langley Field, Va., discovered a way to greatly reduce this transonic drag rise. Whitcomb's method, in essence, says that transonic drag is directly related to the axial distribution of fuselage and wing cross-sectional areas. If the cross-sectional area added by the wings is removed from the fuselage by indenting its contour, then the wing-fuselage combination will have its drag greatly reduced. This theory has been termed "the area rule" for obvious reasons. Whitcomb and other investigators have extended the reasoning behind the area rule for the transonic drag rise to drag conditions in supersonic flight. From this has evolved a modification known as "the supersonic area rule." This study outlines the basic concepts of these two methods.

The Transonic Drag Rise

The sharp increase in airplane drag which occurs at the higher subsonic Mach numbers is due mainly to interference drag caused by interaction of the wings, fuselage, tail and other airplane components.

During World War II, a German aerodynamicist, Kuchemann, made the first flow studies of interference drag effects. Kuchemann analyzed the flow around the wing root of a swept wing-fuselage combination. His studies showed that the flow streamlines turned toward the fuselage at the wing root and then turned away aft of the wing root. He reasoned that if the fuselage were contoured to match the streamlines, the wing fuselage interference at the root would be minimized. American intelligence teams uncovered this discovery and tagged the resulting airplane configuration "the Kuchemann coke-bottle." Unfortunately this name has at times been attached to the more recent work conducted by Whitcomb. The basic difference between the two methods is that Kuchemann's design is tailored to local streamlines while Whitcomb's theory proposes an area equivalence based on the entire stream tube surrounding the aircraft.

Whitcomb's initial approach to the transonic drag rise problem was definitely that of an engineer. Among his questions were the following: What does transonic flow look like and how is transonic drag produced? What are the shock patterns caused by simple wing

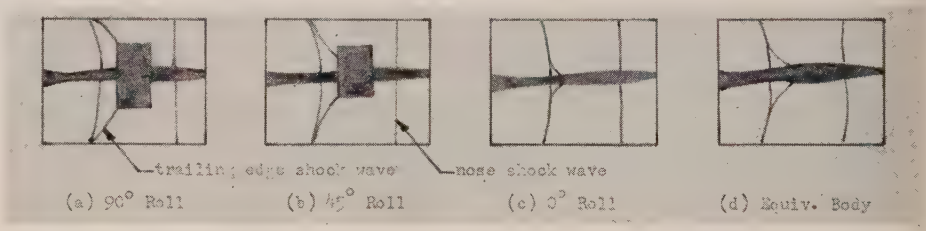

FIG. 1. SHOCK WAVES RESULTING FROM transonic flow past body with straight wing.

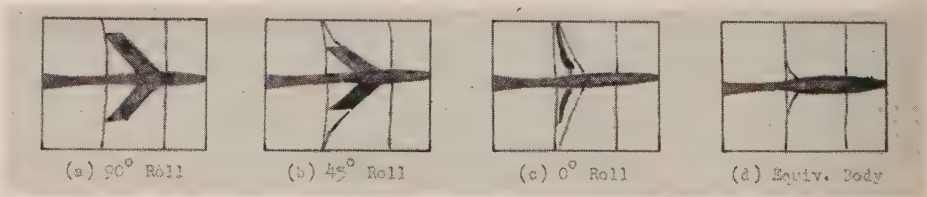

FIG. 2. SHOCK WAVES RESULTING FROM transonic flow past body with 45 degree swept wing.

Vinyl Luggage

With a growing preference for lightweight, inexpensive luggage, the use of vinyl and other plastics in luggage has been increasing at a steady clip, reports *Chemical Week,* McGraw-Hill publication. Today, at least 80 per cent of all luggage made will be covered with some form of vinyl, either fiber sheet or coated fabric.

Delinquent Red Aviators

Russia has charged that several of its air force training institutes are failing to give their students well-rounded instruction, reports *Aviation Week,* McGraw-Hill publication. Even worse, Soviet military chiefs complain, is the lack of initiative often apparent in young officers who have just left an "overly-protective" flying school environment.

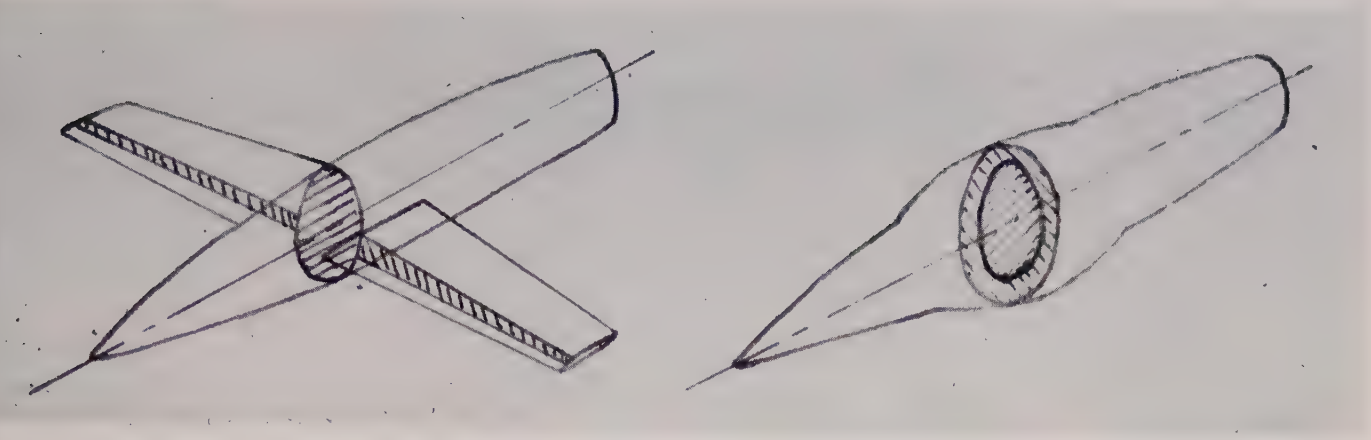

FIG. 3. WING-BODY COMBINATION and equivalent body of revolution differences between a very crude carburetion system and a fuel injection layout are shown in these two drawings, which are simplified to expose basic features of each. (Photos from Motor Life)

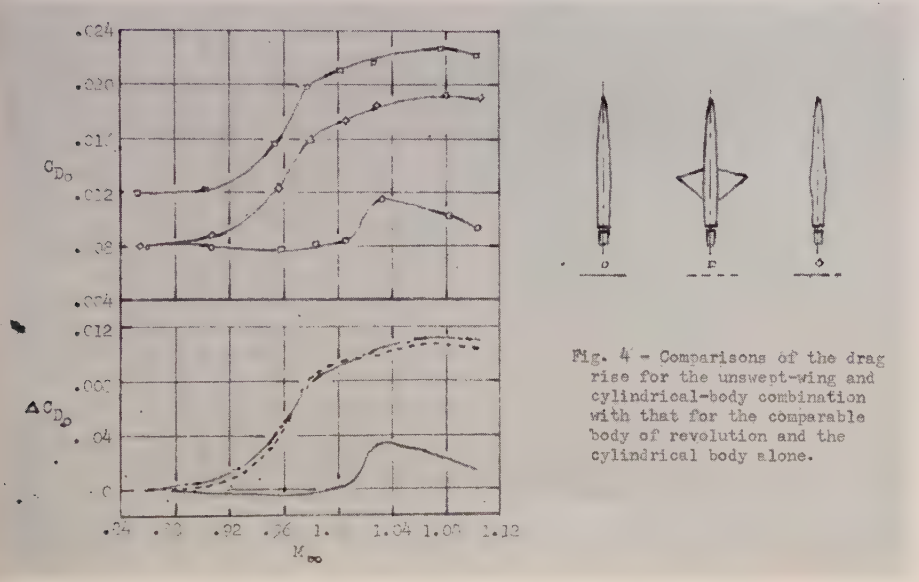

Fig. 4 - Comparisons of the drag rise for the unswept-wing and cylindrical-body combination with that for the comparable body of revolution and the cylindrical body alone.

shapes and body forms? Why does the sharp drag rise occur? How is the drag computed at near sonic velocities, i.e., can the drag of the individual components of the plane be calculated separately and then added or must the entire plane configuration be treated as one interdependent system?

Whitcomb's First Clue

Upon completion of the transonic wind tunnel at NACA's Langley Field installation, Whitcomb began to seek the answers to these drag problems using slender fuselage models and various zero-lift wing configurations. The first significant clue was the strong normal shock noted at the trailing edge of the wing-fuselage intersection in addition to the normal shock near the nose. (It should be noted here that shock waves are possible at high subsonic Mach numbers and are due to accelerated local flow regions where the Mach numbers do reach 1.0).

Equally significant was the fact that this trailing edge shock extended considerably out into the surrounding airstream such that the shock geometry was large compared to the wing-body combination, see Fig. 1 (a), (b), and (c.).

It was this shock geometry at a distance from the body that suggested a dependence on the size of the body rather than on its particular configuration. This prompted a conjecture that the transonic interference drag was due to the axial development of the cross-sectional area of the wing-body combination. With this in mind, a body of revolution having an axial distribution of cross-sectional area equivalent to that of the wing-body arrangement, see Fig. 3, was tested at transonic velocities. The results verified Whitcomb's prediction. As shown by Fig. 1 (d), the comparable body of revolution produced a shock pattern remarkably similar to that produced by the wing-body combination. A comparison of Fig. 1 (d) with Figs. 1 (a), (b), and (c) illustrates this similarity. A like comparison is shown for a swept wing model in Fig. 2.

The measured increments of drag for the wing-body combination and for the comparable body of revolution verified what was expected from observation of the shock patterns. A plot of this drag vs. Mach number for one of the configurations tested is shown in Fig. 4. As can be noted from the plot, the absolute drag coefficients for the comparable configurations vary somewhat, chiefly because of differences in skin friction. Included in Fig. 4 are drag values for the slender body representing the fuselage only.

From the comparable drags of the wing-body combination and its equivalent body of revolution, Whitcomb postulated that a wing-body configuration with the fuselage "trimmed" at the wing junction should have a drag nearly the same as that of the optimum slender body representing the fuselage only.

Models were prepared having the fuselage contoured as dictated by axial developments of the cross-sectional area. The tests of these models were the final proof. The magnitude of drag reduction was enormous. For delta wing planes the drag was chopped by 60% while for swept wing models the drag rise was nearly eliminated for Mach numbers up to 1.04. Above that condition the advantages of the fuselage contour began to lessen.

Application to Full Scale Aircraft

Utilization of the area rule concept for the design of an airplane can be outlined in four basic steps. These are:

1. Plot the cross-sectional area of the initial layout as a function of distance along the longitudinal axis of the fuselage.

2. Compare the area plot with the area distribution of the related ideal body of revolution. These ideal shapes have been derived mathematically by NACA.

3. Rework the area distribution of the first design to agree as closely as pos-

(Continued on Page 34)

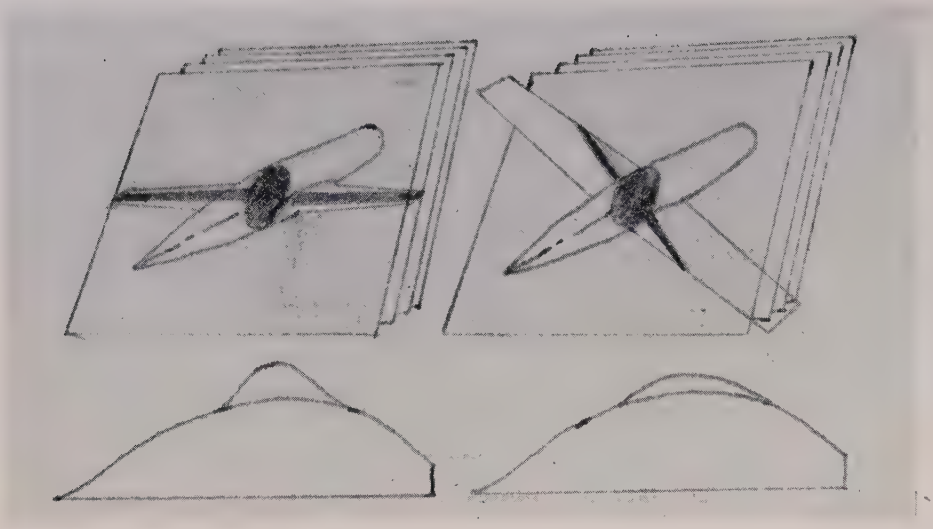

FIG. 5. AREA DISTRIBUTION GIVEN by intersections of mach places

(Continued from Page 33)

sible with the ideal body. Compromises will, of course, be necessary.

4. Convert the new area distribution from the plot back to airplane cross-sections of altering parts of the fuselage radius or removing some of the fuselage sides.

It should be noted that if it is not always necessary to detract from areas in applying the area rule. The volume of the fuselage fore and aft of the indentation can often be increased to compensate for volume lost by the indentation. The added drag of this increased volume is every small compared with the drag saved by contouring the fuselage.

Information on the area rule was first released to the aircraft industry in 1952 on a secret basis. The initial flight proof came with flight tests of the Convair F-102A, the Grumman F-11F-1, and the Chance Vought F-8U-1. All three of these planes seemed doomed to subsonic flight when the first models failed to exceed a Mach number of approximately 0.90. Under arrangements with the industries concerned, NACA sent Whitcomb to the plants to help redesign these planes using area rule concepts. In each case the results were gratifying—in fact, the area rule modified Convair F-102A first broke the sound barrier while in a climb.

The Supersonic Area Rule

Continued testing with the initial area rule showed it to be limited to transonic conditions since its effects were nearly gone at a Mach number of 1.04. Nevertheless, the very simplicity of the area rule suggested a universality that was hard to resist. As a consequence, Whitcomb and Robert T. Jones, also with NACA, presented a supersonic area rule shortly after discovery of the transonic version.

For supersonic conditions the fuselage restriction should be somewhat aft of that dictated by the transonic area rule. The reason for this is that supersonic interference drag is due to Mach waves from the wing-fuselage intersection. These waves extend rearward at the Mach angle until they strike the fuselage, and are reflected. It is this point of reflection that controls the loca-

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tion of area removal from the fuselage.

In extending area rule concepts to supersonic conditions, the cross-sectional areas considered are not those made by planes perpendicular to the stream, but rather those made by planes inclined at the Mach angle, see Fig. 5.

These inclined planes are called "Mach planes." By means of a set of parallel Mach planes an "equivalent body of revolution" is constructed using the areas intercepted by the cutting planes. The drag of this equivalent body is then found using von Karman's formula for the wave drag of a slender body of revolution. It is apparent that the Mach planes may be placed in various orientations simply by rotating them about the longitudinal axis of the fuselage. Each set of Mach planes will determine a particular equivalent body of revolution. Karman's drag relationship is applied to each of these equivalent bodies and the final drag is simply the average of the values obtained by a complete rotation of the Mach planes. The theoretical basis of this step is the fact that the three dimensional fiield about the aircraft can be analyzed by considering a superposition of the one dimensional disturbances found by applying von Karman's wave drag equation to each of the complete set of equivalent bodies determined by the Mach planes.

It should be mentioned that in this method the equivalent bodies of revolution do not have a physical significance as they did for the transonic case. The concept is only an aid in visualizing the drag of the entire wing-body system.

Fewer test results are available in the literature for the supersonic area rule than for the transonic concept. However, sufficient information has been presented to point out that appreciable drag reduction is obtained by using supersonic area rule modifications.

The supersonic regime places additional restrictions on fuselage contouring not present in the transonic flow. Among the most important of these are the following: The fuselage modifications must be tailored for each design Mach number, the fuselage contours have to be sufficiently gradual, and only certain wing-body configurations are amendable to area rule concepts.

Investigations and full scale flight test results to date have proven conclusively that the axial distribution of cross-sections areas is of primary importance in controlling and reducing the interference wave drag inherent to transonic and supersonic flight. As has been pointed out, the area rule is not a cure-all for wave drag problems, but, it is certainly a major stride toward a thorough understanding of the drag difficulties now being encountered in high speed flight.

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MOTOROLA

OUTSTANDING AMONG MEN

Humanitarian, engineer, Ron Karaken receives the first Lisle Abbott Rose Award.

by Phil Philhower, Aero E. '60
and Don Georgi, E. E. '59

The ceremonies of this year's St. Pat's Ball were highlighted by the introduction of a new tradition here at Illinois. An annual award, the first of its kind, is designed to recognize senior engineers proficient in nontechnical areas. At the climax of the ceremonies, Ronald Karaken became the first recipient of the Lisle Abbott Rose Memorial Award.

The rewards of this honor include a gift of $100, and recognition on a new plaque to be placed in Civil Engineering Hall, across from the library. The winner will also receive a small casting which he will be able to keep. The $100 cash award is derived from funds made available through contributions of individuals who feel that the purpose and results of the award are worthwhile. Anyone who would like to contribute to the fund, may make checks payable to the Lisle Abbott Rose Memorial Award Fund, Room 226, Illini Union Building.

The award is presented in honor of Dr. Lisle Abbott Rose, who served our engineering college in public relation and administrative capacities before his death in 1955. Dr. Rose was an unusual personality in that he applied his formal education in the humanities to the betterment of engineering. He first became associated with engineering as a member of the faculty at Michigan College of Mining and Technology.

His previous training and interests in the field of American Literature inspired him to make important contributions to engineering education. He felt that the modern engineer could not live as a valuable asset to society without a broad education and broad interests in the fields outside engineering.

Certain people at the University thought that the attempt to get engineers to take more liberal courses along with the regular courses, could be emphasized by honoring a person who had taken an interest in engineering and humanities. Their efforts resulted in the Lisle Abbott Rose Memorial Award, designed to honor Dr. Rose, and some engineering student who has taken interest in activities and subjects outside the engineering college. The objectives of this award are first, to recognize engineering students who have achieved both technical and cultural proficiency. Secondly, it is to encourage all engineering students to broaden their knowledge by participation in worthwhile activities, and selecting courses outside the engineering college. And thirdly, it is to stand as a tribute to Lisle Rose, who recognized the need for culture in the engineer's life.

The first winner, was chosen because of his outstanding achievements in the engineering field, in academics outside of engineering, and in extra-curricular activities. His name chosen from finalists representing every department of the engineering college, was submitted by the general engineering department. (Nominations for this award can come from individuals who feel that they qualify, or from any departmental or organizational branch of the engineering college.) Final selection of the candidate is made by careful weighing of all the mentioned factors, with an emphasis placed on extra-curriculars.

Along with his major in General Engineering, Karaken has studied rather intensely in the fields of music, philosophy, and Russian. He is an active member of Triangle, the national engineering fraternity, and is currently the vice president of the Illinois chapter. In the past he served as house manager.

As a regular in the Naval Reserve Officer Training Corps, Karaken has twice received the American Legion Award, and is an executive officer. He has been active in choral groups for the past four years at Illinois. Also, he is president of the University YMCA, is a past recorder for the "Y," and is a member of the board.

In his freshman year, he qualified for Phi Eta Sigma. Since then, he has become a member of Sigma Tau, Tau Beta Pi, Tomahawk, and Ma-Wan-Da.

Well, engineers, that's what it takes to win, so junior engineers start working now for next year's award!

FOLLOWING A TESTIMONIAL BANQUET, Ron Karaken receives the first annual Lisle Rose Award from Dean William L. Everitt, as W. W. Hay stands by. (Photo by John Keller)

IMPORTANT ON-CAMPUS INTERVIEWS FOR POSITIONS AT

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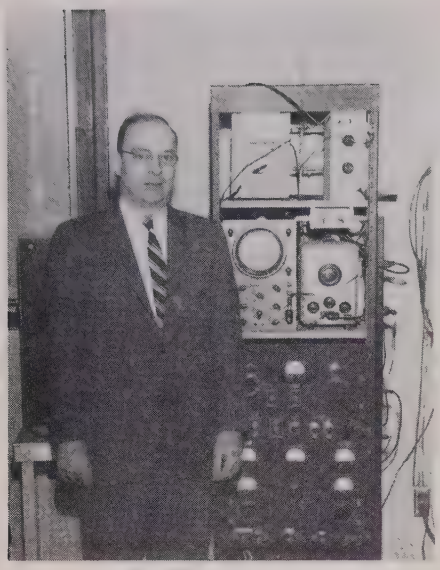
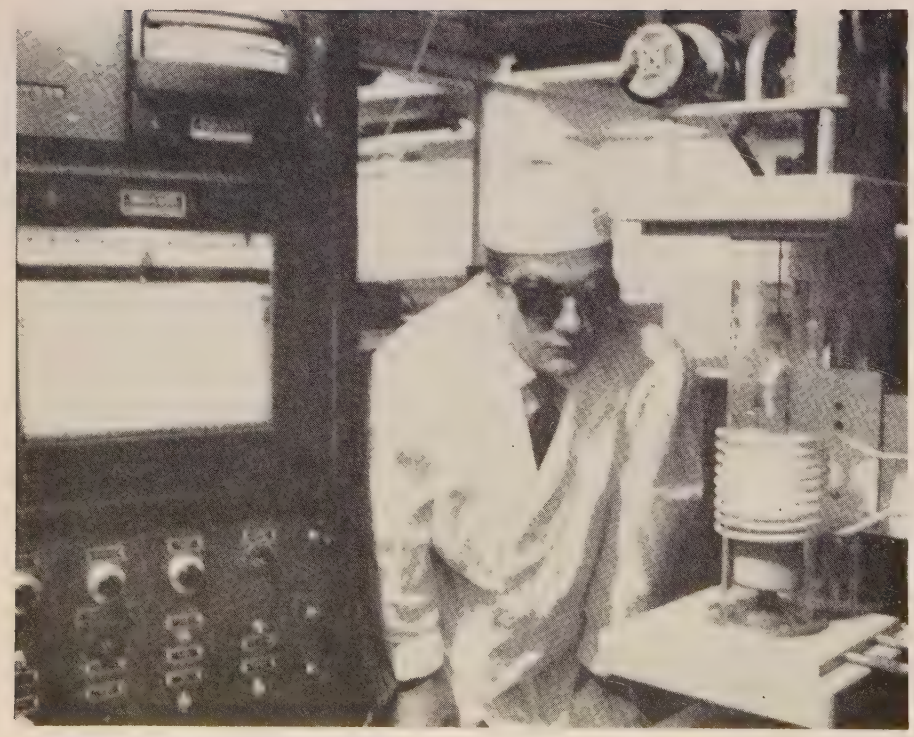


Dr. Bardeen stands by apparatus used in his latest experiments.

Research in semi-conductors wins a Nobel Prize for this UI Professor, who is continuing his research on campus

Dr. Bardeen – Father of th

by Dennis Lantz, G. E. '59



TRANSISTORS, THE TINY POWER DEVICES that are replacing vacuum tubes in many electronic applications are grown in electric induction furnaces.

Dr. John Bardeen is extremely modest. This fact is certainly to his credit, for it seems that it is only those men whose efforts have most benefiteed the world in which we live who are unwilling to give themselves the credit they so richly deserve. In discussing with him his work in the development of the transistor, he continually mentions the contributions of others. Certainly there were many who assisted in the work, but it is typical of Dr. Bardeen to say "we" or "they" when speaking of advancement in scientific research, and fail to mention his own instrumental part.

John Bardeen was born in Madison, Wis., in 1908. His father, Dr. Charles R. Bardeen, was professor of anatomy and Dean of the Medical School at the University of Wisconsin. Although John Bardeen studied electrical engineering at Wisconsin, he took a great deal of extra work in mathematics and physics, a fact which was later to help him greatly. After graduating in 1928, he continued at the University as a research assistant, working on mathematical problems in applied geo-physics and radiation from antennas. It was at this time that he began his study of Quantum theory.

From 1930 to 1933, he worked at the Gulf Research Laboratories in Pittsburgh, Pa., where geophysical methods were first being applied to oil prospecting. Feeling that he preferred the theoretical aspects of physics, he resigned his position in 1933 to take graduate work in mathematical physics at Princeton University, where he first became interested in solid state physics. Before completing his thesis on the theory of the work function of metals, he was offered a fellowship at Harvard, where, fro m1935 to 1938, he worked on problems concerning cohesion and electrical conduction in metals, as well as the level density of nuclei. From 1938 to 1941 he was an assistant professor of physics at the University of Minnesota, but he left there to work from 1941 to

ransistor

1945 as a civilian physicist in the Naval Ordinance Laboratory in Washington, D. C. There, he turned from solid state physics to work on the influence fields of ships and their application to underwater ordinance and mine-sweeping.

Then in late 1945, Bell Telephone Laboratories initiated a basic research program in solid state physics. Early in 1946, semiconductors were chosen as one subject of the project, and S. O. Morgan and W. Shockley were chosen as co-heads. In the original group, under the general direction of Shockley, were W. H. Brattain, G. L. Pearson, and Dr. John Bardeen.

At this time Dr. Bardeen found it necessary to plunge into intensive study of wartime developments in solid state physics, for his work in underwater devices had left him largely out of touch with the field.

Prior to the Bell program, much early work had been done in the field of semiconductor research and theory, but much of this had been hampered by the highly impure state of the materials used. Work in the thirties was largely based on copper oxide and selenium, which have complex structures and varying conductances. Due to this, it was difficult to determine whether the experimental deviations from predicted results were due to faults in the theories or to the poor quality of the materials used. Nevertheless, certain early research was extremely helpful. Wilson's quantum mechanical theory, based on the energy band model, described the flow of current in terms of excess electrons and holes. His theory explains how the concentration of carriers depends upon not only temperature, but also on impurities. Frenkel recognized that flow may occur by diffusion in a concentration gradient, as well as by an electric field, a factor used in the transistor. Independent, though parallel, developments of contact rectification theory had also been worked out by Mott, Schottky, and Davydov, this being another principle used in the transistor. Fortunately, the war had spurred research in germanium and silicon, and as a result, these substances were now available in a highly ure state. It was not, then, a completely unprepared group that prepared to study the properties of semi-conductors.

The basic idea behind the research program was that of more fully understanding the properties of semiconductors. It was not the immediate intention of the group to develop a device utilizing their findings, though the possibility was evident, due to the similarity of a diode radio tube and the rectifying properties of semiconductors. In conjunction with this idea, an attempt was made by Dr. Bardeen and W. H. Brattain to

COLLECTOR CURRENT AND VOLTAGE characteristics of Minneapolis-Honeywell experimental 60-watt power transistors are checked in test labs.

Dr. Bardeen's Work Continues at U. of I.

use an electrolyte to change the surface charge barrier in order to observe the effect of an electric field on conductance. The experiment showed possibilities, but the time constant of the electrolyte limited its use to very low frequencies. It was decided to try replacing the electrolyte with a metal control electrode insulated from the surface, and although this did not produce the desired high-resistance contact, it was tried in order to see that would happen. A small effect was noticed, but the modulated charge glowed in exactly the *opposite* direction as was expected. This was the first indication of the transistor effect. The results of the experiment were analyzed, a theory formulated to explain the phenomenon, further work was done developmentally, and the transistor was well on the road to its syrocketing gain in application to electronic equipment.

Nobel Prize

Then, last year, came the ultimate reward for those in the field of research; the Nobel Prize in Physics was awarded to Dr. John Bardeen for his work in the discovery and development of the transistor. He may be justly proud of this award, for the late Alfred Nobel specifically noted that the prize was to go only to a person who contributed greatly to the advancement of science.

That his achievements have affected his family is evident. His wife is a former teacher, whom he met in Boston and married in 1938. They have three children, James, William, and Elizabeth Ann, and while the daughter is still too young to care for science, the two boys are strongly interested in technical fields. James is a freshman at Harvard and William is a junior at University High School.

Looking Ahead

For not only his own sons but for all others interested in research, Dr. Bardeen feels that there is a vital part to play in the future. As an example, the field of semiconductors is far from being well explored. "We have barely scratched the surface of the possibilities of applications for semiconductors. Their use in electronic and power devices, light amplifiers and photoconductors, in atomic batteries, and in other uses as yet unknown can only be guessed at." The possibilities in the field of research are limited only by the number of men engaged in exploring them.

Commenting on the experiments, Dr. Bardeen admitted that when the results showed that amplification was possible, at least in principle, "We are pretty sure that we had something." As a theoretical research scientist, Dr. Bardeen left the transistor project when the principles were well established and the device workable, to turn his attention to other facets of semiconductor theory. He remained with Bell Laboratories until 1951, when he joined the University of Illinois as professor of electrical engineering and of physics. Since 1945, his main fields of research have been electrical conduction in semiconductors and metals, surface properties of semiconductors, theory of superconductivity, and diffusion of atoms in solids.

That he is renowned in the field of physics research is evident, for he is a Fellow of the American Physical Sosociety and currently a member of the Council, was associate editor of the *Physical Review* from 1949 to 1951 and was elected to the National Academy of Sciences in 1954. Other honors include the Stuart Ballentine Medal of the Franklin Institute, in Philadelphia, the John Scott Medal of the City of Philadelphia, the Buckley Prize of the American Physical Society, and an honorary Doctor of Sciences degree from Union College.

Dr. Bardeen is active in many societies as well as his research work.

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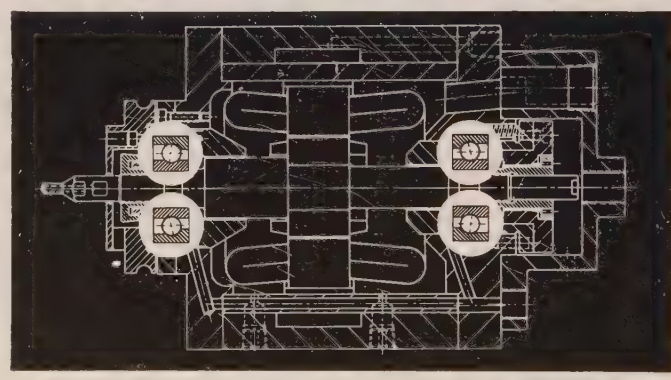

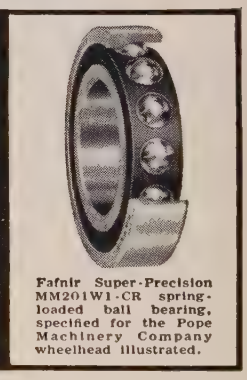

Fafnir Super-Precision MM201W1-CR spring-loaded ball bearing, specified for the Pope Machinery Company wheelhead illustrated.

This Pope-built motorized grinder wheelhead, equipped with its original Fafnir Super-Precision Ball Bearings, has totaled over 14 billion revolutions, operates at 72,000 rpm. Used for grinding the races of extra-precision ball bearings, this wheelhead is still in production-line service.

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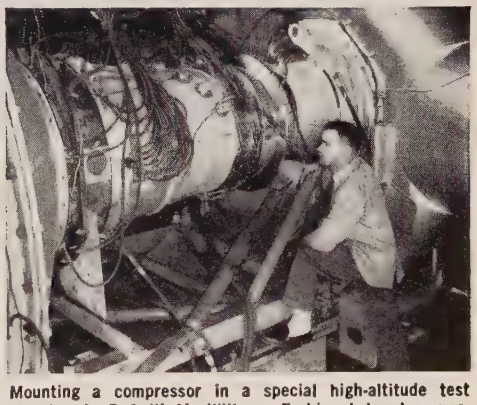
Although the work is demanding, by its very nature it offers virtually unlimited opportunity for the aerodynamicist at P & W A. He deals with airflow conditions in the engine inlet, compressor, burner, turbine and afterburner. From both the theoretical and applied viewpoints, he is engrossed in the problems of perfect, viscous and compressible flow. Problems concerning boundary layers, diffusion, transonic flow, shock waves, jet and wake phenomena, airfoil theory, flutter and stall propagation — all must be attacked through profound theoretical and detailed experimental processes. Adding further to the challenge and complexity of these assignments at P & W A is this fact: the engines developed must ultimately perform in varieties of aircraft ranging from supersonic fighters to intercontinental bombers and transports, functioning throughout a wide range of operational conditions for each type. Moreover, since every aircraft is literally designed around a powerplant, the aerodynamicist must continually project his thinking in such a way as to anticipate the timely application of tomorrow's engines to tomorrow's airframes. At his service are one of industry's foremost computing laboratories and the finest experimental facilities.

Aerodynamics, of course, is only one part of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of instrumentation, combustion, materials problems and mechanical design — spells out a gratifying future for many of today's engineering students.

electronic computers accelerate both the analy- d the solution of aerodynamic problems. Some of problems include studies of airplane performance permit evaluation of engine-to-airframe applications.

Design of a multi-stage, axial-flow compressor involves some of the most complex problems in the entire field of aerodynamics. The work of aerodynamicists ultimately determines those aspects of blade and total rotor design that are crucial.



Mounting a compressor in a special high-altitude test chamber in P & W A's Willgoos Turbine Laboratory permits study of a variety of performance problems that may be encountered during later development stages.

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1. Four members of the Rainbow Club sat down one afternoon to play bridge.

In accordance with the rules of the game, they drew cards from a deck spread face down. The man who drew the highest card chose his seat and the deck to be dealth by his side; second highest took the opposite seat, as his partner; third highest took his choice of the remaining two seats, lowest card becoming his partner.

Without troubling to put the facts in chronological order, we may note that White's card was lower than Brown's. Green asked for a match, which was supplied by White's partner. Black said "What is your choice, partner?" Brown sat on White's left. The left-handed man chose the blue cards, and since Brown is right-handed you can now tell the order of the four players according to the cards they drew.

BRAINTEASERS

2. Suppose a 250 lb. man pushes against a boy weighing 150 lbs. when both are on skates at the center of an ice pond. The average force is 48.3 lbs. and is exerted for 1 second. If then the boy throws a 1 lb. ball to the man at the end of two seconds time how fast is the combined (of the man, the boy, and the ball) center of gravity receding from the center of the pond? Find this for before and after the ball is thrown, and for before and after the ball is caught.

3. For you fellows who like probabilities, here's a little problem. Figure out the probability that a stick, being broken into three chance pieces, may be arranged in the form of a triangle. Realize that if a 12″ stick is broken into two pieces 2″ long and an 8″ piece, no triangle can be made.

4. One lucky engineering student who had just braved five hour exams during the day, decided to relax by taking a ride on his new convertible motor scooter equipper with full race mud flaps. As he sped merrily down the road, thinking of nothing but how neat it was to go briskly down the road with his slide rule flapping at his side, he unconsciously attempted to occupy the same place in space with a weary-eyed architect, who was trying to get a clay model abstraction to the south side of campus before five o'clock. The resulting collision created a dandy conservation of momentum problem that we aren't going to worry about now. When the engineer picked himself up, he saw that the clay abstraction (now dearranged) had a perfect impression of his license plate stamped on it. "Say Claude," exclaimed our engineer, "look at the neat impression you now have on your model."

"Thanks Gus," replied the architect. "But you've got the model upside down!"

"No, no! See the 'Illinois' printed at the bottom!"

"Idiot! I say it's upside down!"

"Whassamatter, do you guys always carry your models upside down?"

"What difference does it make!" groaned the architect.

"Don't you see, Claude? If I hit your model with my license plate, while you are carrying it right-side-up, the state name below the numbers will still be below the numbers on the impression, so yo uwere carrying the model like this."

"Look again Einstein, you have the state name above the numbers, and the 'Illinois' is upside down on your scooter."

"Say, you're right. My plate is upside down. I must have put it on that way, because all four bolts are still on."

Upon further inspection, our engineer found out that the plates were readable both right-side-up and upside-down. He further noted that the upside-down number was 78,633 larger than the right side-up number. All five of the figures were different. What was the number of his license plate?

MARCH ANSWERS

1. A yellow to red fiame test eliminates Cu and Ba (both green).

If Ag had been present it would have reprecipitated with HCl.

Mercury must be absent or the filter and/or the filtrate would have yielded a black precipitate (through reduction by ammonia).

The first sulfide precipitate was gray; a yellow precipitate would have been partially visible, but since it was not in evidence, Cd, As, Sb, and Sn must have been absent. The absence of a colored borax bead test eliminated Co, Fe, Mn, and Ni.

No precipitation from an acid solution by NaOH eliminates Zn, Cr, Al. This eliminates all of Group III.

After precipitating the carbonates the solution was composed entirely of volatile material. Hence the alkalies must be absent. The absence of a fiame test through cobalt glass elminates Sr. The hydroxide precipitate was not affected by p-nitrobenzeneazoresorcinol, hence Mg is absent. This leaves only Pb, Bi, and Ca.

To complete the analysis it is necessary to take these cations through the reactions.

Ca accounts for the yellow to red (orange) flame test. Bi hydrolyzes and precipitates at a pH of 6. Pb is precipitated as a chloride, and is soluble in either hot water or strong base. Pouring HCl into the alkaline filtrate would give a hot solution which keeps Pb from precipitating.

Bi hydrolyzes at a pH of 5. Hence the first sulfide precipitate is solely one of Pb which sulfide is (or may be) gray.

The second sulfide precipitate is both Pb and Bi. Digestion on the filter with NaOH dissolves Pb to a certain extent. Neither Pb nor Bi will color a borax bead.

The sulfate ion will precipitate Pb, and turbidity may be caused by a dilute solution of Pb, H_2SO_4 might also oxidize the small amount of sulfide ion present.

The filtrate after sulfide precipitation will, of course, contain Ca, and since Pb in strong base is present as the plumbite ion, Calcium plumbite will leave solution.

Calcium plumbite in acetic acid will produce again the Pb ion as a cation which precipitates with the addition of a chromate. Since this is one of the tests for Pb, step nine was a dead giveaway.

Carbon dioxide will precipitate Ca in a basic solution. Pb and Bi will already be out as hydroxides. Dissolving and reprecipitating leaves Ca in solution and its flame test is not visible through a blue filter. S and O reagent does not color the hydroxides of Pb and Bi. Thus the analysis is complete. All the phenomena may be attributed to just three ions: Bi and Pb from Group II, and Ca from Group IV.

2. I doubt if many of you were able to work the second problem, mainly because you didn't know what was asked for. The problem should have gone on to say that he overtook the hat in five minutes at a point just opposite his house. What was the speed of the river current? The answer is 6 mph.

3. AB = 5.36 ft.
   BP = 1.27 ft.
   Minimum distance = 6.63 ft.

Over 10,000 visitors from all over the state visited

UI Engineering Open House on the North Campus

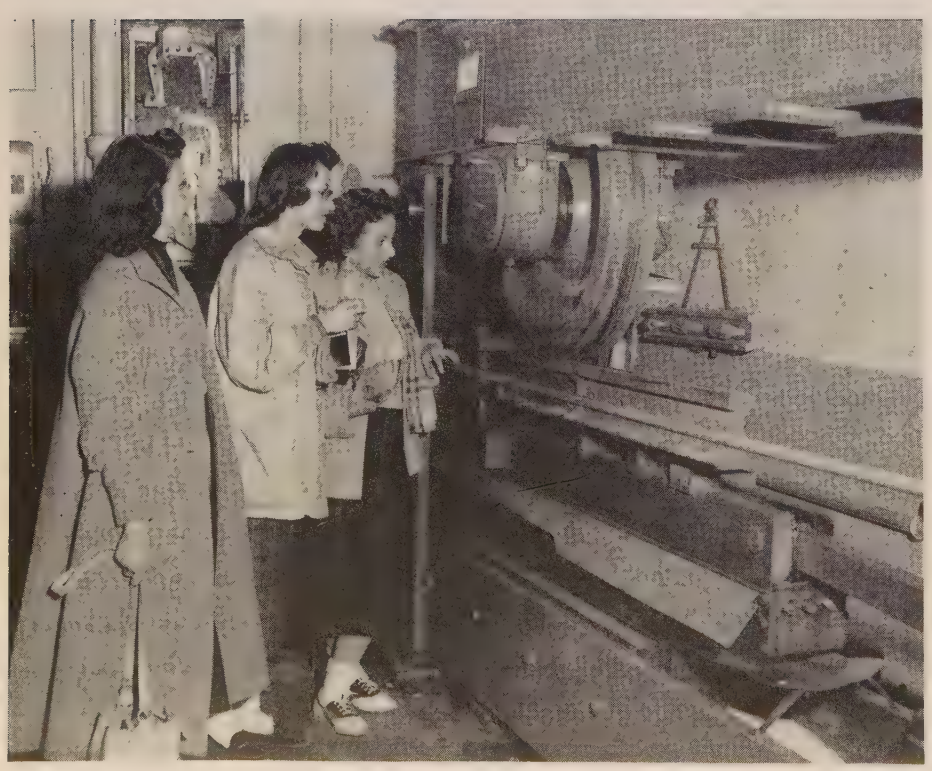
March 15-16, 1957, and came away impressed.

Open House - 1957

LAURIE BAIER (lower left) ST. PAT'S BALL queen and ASME candidate, poses with her court. They are (clockwise from Miss Baier) Jeanne Ricks, AFS; Ann Mitchell, MIS; Delores Hodges, IES; Garland Borne, ASAgE; Ann Alloway, AIEE; and Queen Laurie. (Photo by George Hart)

Little Lana Dalrymple of Urbana, perched on a weight gage in Talbot Lab. The shaped beam of prestressed concrete measured her at 41 lbs.

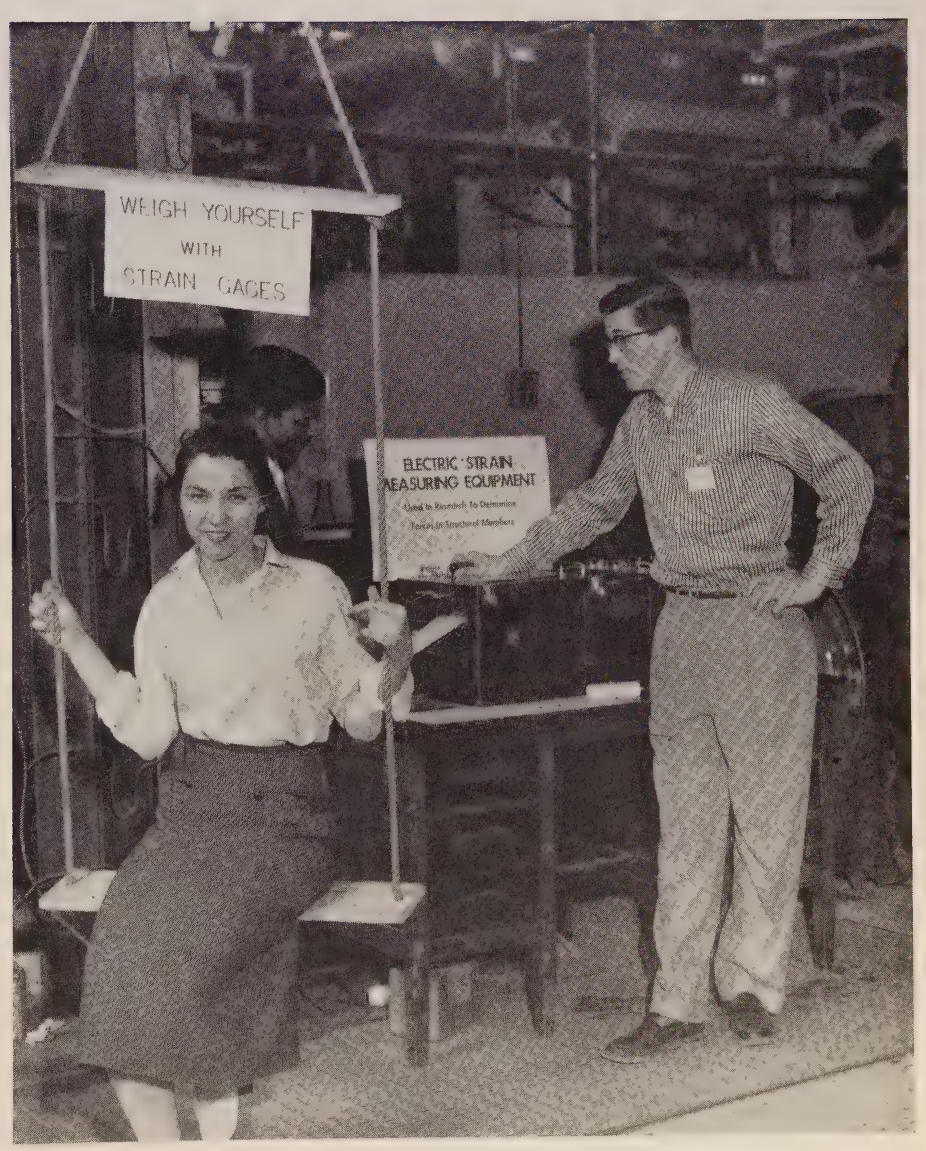
THE DISTAF



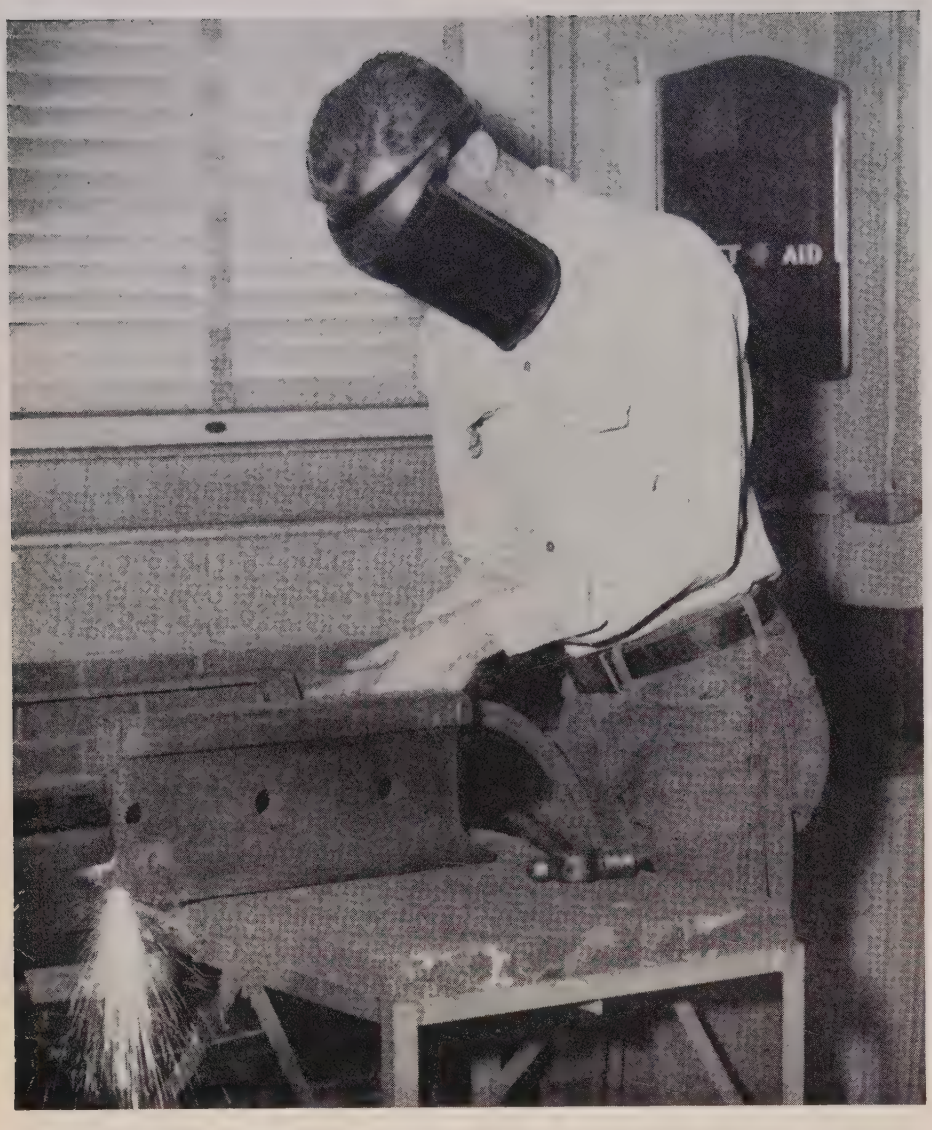
Herrin co-eds Pate Kane, Jenny Sanders and Rosalie Conti view the rail testing device in the basement of Talbot, which runs a wheel thousands of times over a piece of rail for failure.

Many members of the "weaker" sex came and saw and demonstrated many of the devices on display.

SIDE

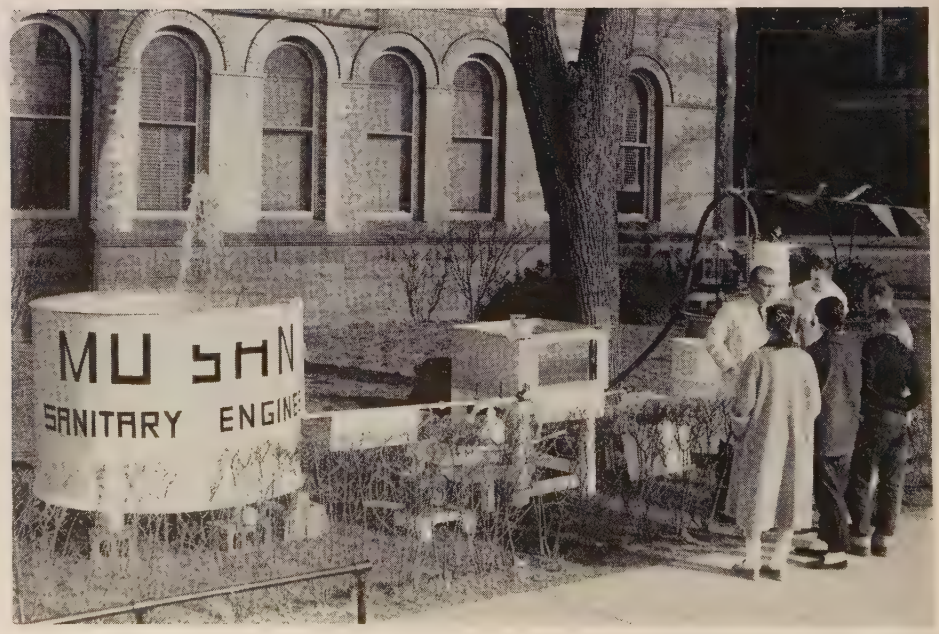


Gerry Komosa, (Psych '59) weighs herself on the Ag Engineering weighing device in M. E. Lab. Checking the strain gages are Thomas Nirmal, Ag. E. Grad student and Don Smith, Ag. E. '58.



Engineers Demonstrate Their Skills

Les Lantz, M. E. '57, demonstrates metal cutting techniques with torch in Mechanical Engineering Building.



Water Purifier outside of Civil Engineering Hall, took Boneyard water and made a solution somewhat more palatable out of it.

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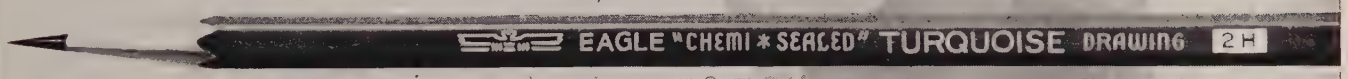

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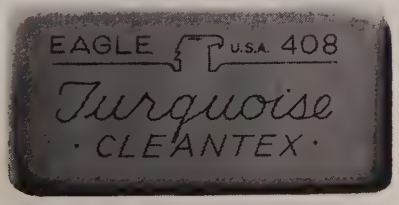

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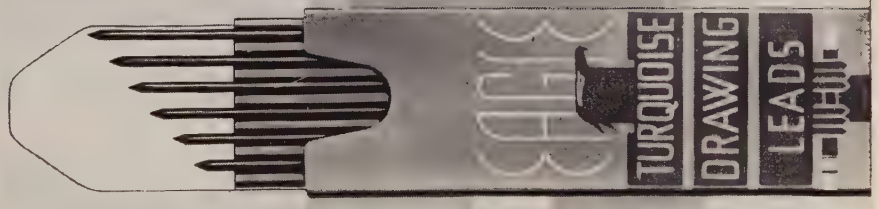

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A Guide to

GAGES

One of the most important aspects of engineering is accuracy. And one of the most important means of obtaining accuracy is by using the proper instruments to measure. The following two-part article is concerned with the various types of gages in use.

For purposes of classification the gages described here in will be divided into two general categories namely: non-precision, line-graduated measuring instruments and precision instruments. Although in many instances it is difficult to differentiate between a non-precision and a precision instrument, for usage in this manual a non-precision instrument will be a line-graduated instrument such as steel rules, calipers, depth gages, etc., where accuracy is determined by the users ability to line up and read graduations on a scale. In other words, measuring is done usually in fractions of an inch instead of thousandths of an inch. This group will also include such instruments as dividers, outside calipers, etc., in which the sense of feel plays a large part in the determination of accuracy. Accuracy of precision instruments generally will be determined by the accuracy with which it was made and usually the measurement is in the thousandths of an inch or finer. Many of these gages have mechanical, optical or electronic methods of magnifying small units of length into distance large enough to easily be read. Determining the type of instrument to use will depend largely upon the physical characteristics of the part to be gaged and also the required accuracy. No instrument is capable of measuring any more accurately than the small graduation. For instance a dimension cannot be read any closer than 1/32nd on a 1/32nd scale. If the dimension lies between the scribed lines, only a guess can be made. If it is necessary to read more accurate a 1/64th inch scale should be used, or another type of gage of known finer accuracy should be used.

A. Steel Rules

A simple tool commonly used is a scale scribed on a strip of steel of varying lengths. Generally the scale is graduated on four edges from 1/8″ to 1/64″ or from 1/10″ to 1/100″.

Accuracy of measurement is dependent on the smallest graduation and the experience of the inspector but should never be depended on if closer than 1/64″ is necessary. The error of the scribed lines is listed at .0005″ for every six inches of rule.

Application of the steel rule is limitless but generally it is contingent upon the type used as listed below:

1. *Tempered Steel Rule*—Commonly six inches long and graduated to 1/64″ although a large variety of scales are available. The rule may be thin tempered steel to allow measurement of curved surfaces, tapered to allow measurement across corner fills or fillets, or even scribed on the ends for measurement in restricted locations.

2. *Hook Rule*—The hook rule is a standard steel rule with a fixed shoulder attached to one end to facilitate measurement from shoulders. It is especially useful in cases where the end of the rule is hidden so that the scale graduations cannot readily be seen to be aligned with the end of the part. Frequently a hook rule is used to set inside calipers or dividers.

3. *Steel Rule with Holder*—The steel rule with holder consists of a short rule and a holder slotted at one end to allow for the insertion of the rule. The rules are available in several sizes ranging from ¼ to 1 inch. The steel rule with holder is used primarily to measure in restricted places.

4. *Depth Gage*—A depth gage is essentially a steel rule equipped with a sliding shoulder designed to bridge a hole or a slot so that the depth of the hole or slot can be measured in reference to the face. Various adaptations of depth gages are available; among them rod type where a rod is used to facilitate measuring into small holes; hook type to allow measurement of holes extending completely through or a protractor type which enables the inspector to place the rule at an angle in relation to the sliding head to check chamfers and angles with a rough degree of accuracy.

5 *Plain Protractor*—The plain protractor used in the machine shop and on the drafting table consists of a steel rule, the end of which swings over a scribed plate. The plate has a scale divided into degrees from 0° to 180°. Angles can be measured by laying the edge of the rule along the surface of the bevel or lines can be drawn along the edge when used for layout work.

6. *Try Square*—Sometimes referred to as a right angle gage, the try square

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is available in a variety of styles and sizes. Used to inspect lines and surfaces at right angles to each other, the try square consists of a blade which may or may not be scribed and a beam mounted at right angles to the blade. If the blade and beam are mounted rigidly to one another the try square is considered a precision gage. With experience and training a high degree of accuracy can be obtained. As a non-precision gage the blade is removable and the gage should be used only for a rough check. Many times feeler gages are used in conjunction with the square to measure the squareness of one surface to another. The inside corner of the intersection between the beam and the blade is usually recessed so that burrs on the edge of the part will not effect the accuracy of the square.

7. *Combination Square*—The combination square contains the features of the steel rule, protractor, try square, center head, and sliding head and beam. The steel rule can be used separately or in combination with the various sliding heads.

With the common sliding head, the combination square can be used to measure squareness between two surfaces and at the same time it is possible with the use of the spirit level on the head to determine whether one of the surfaces is plumb. By setting the steel rule flush with the sliding head, the square can be used as a height gage. With the use of the miter edge 45° angles can be laid out as well as 90° angles.

The protractor sliding head enables the measuring and laying out of the full range of angles from 0° to 180°.

By inserting the rule into the centering head, cylindrical surfaces can be measured. The center head is slotted so that when the rule is inserted, it bisects the 90° angle of head. The measuring surfaces then are tangent to the surface of the cylinder and therefore the center of the cylinder can be found.

8. *Slide Caliper Rule*—The slide caliper rule consists of a steel rule with a long fixed shoulder and a slide. The fixed shoulder and the slide are so arranged that either inside or outside dimensions can be read on the scale. The slide caliper rule is used mostly to measure outstide and inside diameters of objects.

B. Dividers and Calipers

Instruments frequently used with steel rules are dividers, outside calipers and inside calipers. They in themselves are incapable of being read directly, they only hold a measurement so that it can be transferred from the object measured to a graduated instrument such as a steel rule or micrometer calipers.

1. *Dividers*—A divider is an instrument consisting of two sharp points held apart by a spring and adjusted by means of a screw and nut. It can be used to scribe an arc, radius or circle or it can be used to lay out a distance set from a rule or to transfer a distance for measurement to a rule.

When setting a distance on a rule the usual procedure is to set one point of the divider on an inch graduation (do not set to end of rule) and with the use of the screw adjust the other point to the desired graduation. It is necessary to keep the points sharp in order to get a fair degree of accuracy. The accuracy of the dividers is largely dependent upon the accuracy of the rule used, thus, should never be used where accuracy greater than 1/64″ is necessary.

2. *Outside Calipers*—The outside calipers differ from dividers in that it is possible to measure distances over and around surfaces and transfer the measurement to a scale. These calipers came in a wide range of styles and sizes, the most common of these being a firm joint claiper and a spring caliper. The firm joint caliper is more adaptable to larger work and is quicker to adjust. The legs are held in position because of the friction of the joint by which they are fastened. The setting is not held tightly by this arrangement.

The legs of a spring caliper are held against a nut on a screw. By turning the nut, the legs can be adjusted to the proper size. To adjust an outside caliper to a scale, the one leg should be held firmly against one end of the scale and the other leg is then adjusted to the desired dimension.

To adjust the outside caliper to the work, the legs should be opened wider than the work and then adjusted to it. The sense of feel is very important in order to get as close a reading as possible. Only practice and extreme care will eliminate th epossibility of error in using the calipers.

3. *Inside Calipers*—The inside caliper has the same general function as the outside caliper except that it is used to measure inside dimensions. Generally the same type of inside calipers are available as there are outside calipers. Again it is well to note that the sense of feel and the proper use of calipers is necessary in order to obtain the desired accuracy.

C. Vernier Instruments

The principle of the vernier scale is applied to various instruments; the most common of these being: vernier calipers, vernier height gages, vernier depth gages, and vernier protractors.

The feature of a vernier scale is a short auxiliary scale having one more graduation in the same length as the main scale. Because of this, a division on the vernier scale is proportionally smaller than the corresponding division on the main scale. For example, if the main scale is divided into 24 equal divisions, the vernier scale is 1/25 smaller than each division on the main scale. If the main scale is so divided that each division equals 1/40 of an inch and each vernier scale division is 1/25 smaller than the main division, then 1/25× 1/40 equals 1/1000 or .001″.

The accuracy of Vernier Type gages as with all scale type gages is only to the smallest graduation. Many times when gaging a part the sense of feel becomes a factor which only compounds the error already present in the gage. Therefore these gages should only be used for such dimensions that have fairly large tolerances and for layout work where some variation from the basic dimension will not effect the finished part.

1. *Vernier Calipers*—The vernier caliper consists of an L-shaped frame the end of which is one of the jaws. The long arm is graduated and may be up to 48 inches long. The sliding jaw contains the vernier scale. The sliding jaw consists of two sections joined by a screw. By clamping the larger section in its approximate position, a fine adjustment can be made by turning the adjustment screw.

2. *Vernier Height Gage*—The vernier height gage is an adaption of the vernier caliper with a special foot to be used on a surface plate. The adjustable jaw is so made that a scriber or an indicator can be mounted on it. The height gage is especially useful in layout inspection or to find location of holes and surfaces.

3. *Vernier Depth Gage*—The vernier depth gage is similar to the rule depth gage and the depth micrometer. It is used to measure depth of holes, slots, counterbores, recesses, etc. Generally a vernier depth gage can not check a hole less than ¼ inch in diameter, but it can check slots as small as 1/32 inch.

4. *Vernier Protractor*—The vernier protractor is an adaptation of the plain protractor so that angles can be read to a closer degree of accuracy. It's uses are generally the same as those of a plain protractor and that which is found on a combination square.

The main scale on a vernier protractor

is divided into four quadrants of 90° each. The scale starts at 0° and increases to 90° then decreases to 0° again. To account for the fact that the main scale does increase and decrease, the vernier scale must do likewise and since the main scale has a zero center, the vernier scale does also. Therefore when the main scale runs from right to left, the vernier running from right to left must be used and if the main scale runs from left to right the vernier must do likewise.

The vernier scale running from 0 to 60 is equal to 23 divisions on the main scale. Each graduation on the main scale equals 60 minutes and therefore 60×23 equals 1380 minutes. Each pair of graduations is equal to 120 minutes. The vernier scale has 12 graduations spread over the 1380 minutes making each graduation equal to 115 minutes. The difference between the main and vernier scale graduation then equals 5 minutes.

D. Telescoping Gages

To facilitate the reading of measurements where a micrometer or calipers can not be used, a gage known as a telescope gage may be used. The gage consists of a telescoping lever attached to a handle at right angles to the lever. In use, part of the lever telescopes into the other part and is held against the work by a spring. A screw located in the end of the handle can be turned, holding the telescoping member in place, making it possible to remove the gage from the work and measuring it. The telescoping gage is adaptable to rough bored work and odd size holes where there are no plug gages available.

E. Small Hole Gages

The small hole gage may be used for the same general measurements as the telescope gage, except for smaller work. The ball point of the gage is inserted into the hole and by means of a taper plunger, can be expanded to fit the hole. Small hole gages are made in sizes ranging from ⅛" to ½".

F. Micrometer Calipers

1. *Plain Micrometer Caliper*—The micrometer caliper utilizes the relationship between the axial and circular motions of a screw as a means of precision measurement. It consists of a U-shaped frame and a screw. One end of the U holds an anvil and the other carries a hollow steel barrel in which the screw turns. Graduations along the barrel and around the thimble translate the axial movement of the screw in to linear dimensions. The most common micrometer is from 0 to 1 inch. The larger size micrometers measure within a range of 1 inch but the distance between the anvil and spindle is larger. For example, on a 2 inch micrometer 1 inch must be added to the barrel reading to give the correct distance.

Directions for reading a Micrometer Caliper

The distance between the anvil and the spindle is determined by the number of turns or fraction of turns of the screw. The screw on a standard inch micrometer has 30 thread per inch and therefore, for each revolution, the screw open the micrometer calipers 1/40 or .025 inch. The barrel is graduated to show each revolution of the screw, having 40 graduations for the complete range. For convenience every fourth graduation, representing one tenth of an inch, is numbered. The thimble is graduated so that each 1/25 of a turn is indicated (1/25 of 1/40 or .001 inch) by one graduation. For convenience every fifth graduation is numbered on the thimble. To read the micrometer caliper, note the highest number visible on the barrel, add to this any dditional graduations and then add the graduation on the thimble.

In cases where the thimble zero approaches the index line on the barrel, care must be taken so that an additional .025 isn't added. The next graduation of the barrel may show but has not actually become a portion of the barrel reading. Care also must be taken in the amount of measuring pressure that is used. The "feel" of micrometer may be accomplished by measuring standard gage blocks.

2. *Inside Micrometer Calipers*—Inside micrometers are designed for measuring small holes, slots or other small inside dimensions. The minimum dimension is determined by the width of the tips of the jaws. The scale on the barrel runs from right to left instead of from left to right. Inside micrometers (tubular) are used to measure inside dimensions larger than those generally covered by an inside micrometer caliper. By the use of extension rods, inside micrometers can be made to measure almost any size inside dimension.

3. *Micrometer Depth Gages*—Micrometer depth gages consist of a flat base attached to the barrel of the micrometer. The spindle of the micrometer protrudes from the base. It can be used for measuring depths of holes, steps, flanges, and other surfaces not easily bridged by measuring anvils of other types of gages.

4. *Vernier Micrometer Calipers*—The vernier micrometer caliper is a standard micrometer caliper with a vernier scale. This vernier scale it etched on the barrel in line with the thimble scale. It consists of 11 equally spaced lines numbered from 0 to 9 with an additional 0 at the other end. The first 10 graduations occupy the same space as 9 divisions on the thimble; therefore, one vernier division equals $1/10 \times 9/1000 = 9/10{,}000$ inch. The difference between the thimble and the vernier divisions are 10/10,000 minus 9/10,000= 1/10,000 inch, thus allow a reading of 1/10,000 of an inch. Whenever the thimble graduation does not coincide with the index line on the barrel the vernier scale will be used. Never use the numbers of a thimble scale graduation that coincides with a vernier scale to obtain a vernier reading.

If the thimble reading is exactly .019 then the vernier scale does not enter this reading except to verify the apparent position of the thimble scale on the index line. Frequently the measuring anvils on a standard micrometer will not be accessible to the dimension to be checked. For this purpose special anvils or special micrometers are available.

5. *Blade Micrometers*—used basically to check grooves and slots—the spindle is of such design that the blades will not turn.

6. *Flange Micrometers*—the anvils are ½ inch discs, .020 of an inch thick at the ends to measure flanges ⅛ of an inch deep and with a clearance of .020 of an inch.

7. *Screw Thread Micrometers*—The anvil has a truncated groove to fit a thread and the spindle has a truncated cone tip. Because the size of the thread increases as the pitch diameter increases, screw thread micrometers are made in various sizes.

G. Plug Gages

1. *Plain Plug Gage*

The cylindrical plug gage is merely a cylinder ground to the required degree of accuracy as to roundness, size and finish. The cylindrical plug gage may be a single-end type being used only to check one size. A double-end cylindrical plug gage has a "Go" cylinder on one end and a "No Go" cylinder on the other with handle to separate the members.

It is important with all types of plug gages that the force or torque applied is no greater than that which can easily be applied on the gage handle. Excessive force applied to a "Go" will tend to distort the part and result in acceptance of an unacceptable product. Hand torque no more than is necessary to wind a spring driven clock, is adequate to insure proper inspection and under no circumstances should a wrench or lever be used to force a thread gage in a part.

Care should be used to align a plug gage with the part and in case of seizure, extreme caution should be used to remove the gage. A soft object such as a piece of wood or brass may be used to gently tap the plug out. If this fails, the plug and the part should be taken to the supervisor for removal.

2. *Progressive Plug Gages*

A progressive plug gage is made with the front cylinder smaller than the back. This enables a "Go" and "No Go" check with the single end.

3. *Special Plug Gages*

The variety of special plug gages are practically infinite. There are taper plug gages to check tapered holes and thread plug gages to check internal threaded holes. Miscellaneous plug gages to meet specific conditions include taper threaded pipe plug gages, spline plug gages and flat plug gages.

H. Ring Gages

The plain ring gage is an external gage of circular form employed for the size control of external diameters. For sizes between .59 to and including .510 of an inch ring gages are made of a hardened bushing pressed into a soft gage body. The thickness of the gage will range from 3/10 of an inch to 1 5/16 inches. For sizes between .510 of an inch to 1.510 inches, the blank is the same as the other except that it is made of one piece—no bushing is used. Ring gages from 1.510 to 5.10 inches are made with a flange to make them lighter and easier to handle. Ring gages above 5.510 inches in size usually come with handles for convenience of handing.

Ring gages are used to check the outside diameter of shafts, arbors, studs, pins, balls, etc. They can check for size, taper and out of roundness all in one trial where as other gages could not give such a complete inspection.

The part should be lined up with the hole and gently pressed in. If the piece refuses to go in with gentle pressure on the "Go" gage then the piece is oversize. If the piece goes in on the "No Go" then the piece is undersize. A point to remember is that the "Go" *Ring* Gage controls the maximum dimension on an external dimension and the Go *Plug* Gage controls the minimum dimension on an internal dimension.

Various ring gages include twin ring gages, taper ring gages, and receiver gages. Other special ring gages are made to meet specific needs for parts such as eccentric shafts, splines, etc., that is, the top of the teeth are ground off, so as to check only the pitch diameter. By cutting off the threads on the "No Go" gage contact with the sides of the teeth is assured.

I. Thread Gages

1. *Thread Plug Gages*

To check a hole properly with a thread plug gage, the "Go" gage must be screwed into the hole until it is at least flush with the other end or in case of a blind hole, until it bottoms. The "No Go" gage should just start in the hole and should not enter more than a turn and a half.

Care should be taken in handling thread plug and ring gages. The life of the gage is determined more by its handling than by any other factor. Dirt, grit, chips, etc., will reduce the life of the gage. Great force should never be applied and in no case should a thread gage be used as a tap.

2. *Thread Ring Gages*

Thread ring gages are usually made with three slots cut radially from the center—two of these slots terminate in holes; the third is cut all the way through. A screw arrangement through the third slot permits a degree of adjustment to the gage.

3. *Taper Thread Gages*

Taper threads are used as a means of joining sections of pipes and pipe fittings; on plugs to seal drain holes; and generally to form a tight fitting leakproof joint to contian a gas or fluid. The form of the thread has a higher crest to make for a tighter fit and it is tapered. The standard taper is three-fourths of an inch per foot measured on the major or pitch diameter.

Construction of the thread plug and ring gages is similar to the construction of plain plug or ring gages. Thread plug gages are usually equipped with a slot along its length to help remove chips.

The standard taper thread gage consists of a single member on which a flat has been ground. In gaging the hole, the gage is screwed into the hole until it is hand-tight. The flat then should be lined up with the face of the hole. The standard working tolerance is plus or minus one thread; the standard inspection tolerance is plus or minus one and one-half threads. In other words, when the gage is firmly inserted, th eflat will never be more than one and one-half threads in the hole or more than one and one-half threads away from the face of the hole. Some taper plug gages have "Go" and "No Go" flats ground onto them to expedite checking.

4. *Supplementary Thread Gages*

To supplement the taper thread plug gage there are two other gages, one is used to check the length of taper and as well as the correctness of taper. This is to make sure that when it is made wrench tight the joint will be correct.

5. *Plain Taper Gages*

The other gage is a plain taper gage which is a smooth tapered gage. This checks the minor thread diameter, the amount of thread truncation and taper. It is necessary to use this gage for these dimensions because the threaded gages have to have the root of the threads undercut to permit grinding of the tooth form.

6. *Single Ring Gages*

External pipe threads may be checked with a single ring gage. The same general inspection holds true for the ring gage as did for the plug gage.

Various other methods of checking threads are used; thread snap gages, scre wpitch gages, measurement over wires, thread micrometers, shadowgraphs, etc. One disadvantage of checking threads with thread plug or ring gages is that all the errors are checked at once and it is possible that on certain threads, a distinction needs to be made.

J. Test Indicators and Dial Gages

1. *Dial Indicators*

A dial or test indicator is a mechanism for amplifying and measuring a small displacement. It consists of a contact point attached to a multiplying lever system, gear train, or other amplifying means operating a pointer relative to a graduated dial, dial sector, or scale with suitable means for attaching rigidly to a support, a gage or a measuring instrument. It is used for comparing the dimensions of a piece of work with contact length standards, or measuring variations from a standard measurement. A sharp distinction between dial indicators and dial test indicators cannot be made, but in general a dial indicator operates through a longer range than a test indicator.

In short the dial indicator is a means of comparing a piece of work to a standard. The indicator amplifys small linear displacement, but in itself is almost useless without being attached to something. Once it becomes attached, it can become one of the most useful of all inspection instruments. Even though the dials on the indicator may be graduated

in quarter-lengths, half-tenths, ten thousandths, thousands or five thousandths, they are always classified as 1/1000 ths, or 1/10,000 indicators. The most common indicator is the 1/1000th model. Although it can easily control the accuracy of .001 of an inch, its graduations probably will be as small as ¼ of a thousandth. The scale on the dial is usually of a balanced type and reads both to the left and to the right of zero. When properly set up, the dial will be set at zero and any reading to the left would be considered minus and any reading to the right would be considered plus. Most new dial gages are set so that the dial comes to a stop at one quarter turn to the left of zero. This is so that there will be tension on the mechanism when the gage is set at zero and allow for a reading on either side of zero. The dial is mounted on a bezel and may be adjusted to any position simply by turning the knurled rim. Some dials have a clamp which can be used to hold the rim firmly in place once it has been set.

2. *Dial Depth Gages*

A dial depth gage is similar to a depth gage where the shaft is attached to the dial indicator. It is used to check counterbores, steps in holes, etc.

3. *Dial Gage Comparators*

The dial is mounted on a pedestal and the table is adjustable to allow for a wide range of work. Usually set with a master gage; the comparator can be used to compare to the master quickly and with a great degree of accuracy. A dial caliper gage (Zissors Caliper) is useful to check thickness of webbs on castings and forgings. It has the advantage over the transfer caliper in that it doesn't have to be removed from the work to be read.

4. *Dial Snap Gages*

With the advantage of the snap gage this gage goes one step farther in that a direct reading can be made; also by revolving the part in the gage, out of roundness can be checked.

Mounted on a surface gage, the dial indicator can be used to check out of round conditions, run out, out of square, taper, etc., the work being held between centers.

5. *Dial Bore Gages*

To check diameters, out of roundness, taper, bell shape, etc. of holes, a dial bore gage can very accurately be used. By detaching the points, a variety of sizes of holes can be checked with the same head.

Although the dial indicator gages now manufactured are surprisingly rugged, it must be remembered that they are made up of parts as delicate as that of a watch. Care should be taken that they are not abused. If the case is damaged or dirt and grime get into the case, the dial can become sluggish and of course effect the accuracy of the measurement.

6. *Universal Surface Gage*

The universal surface gage is a measuring tool used primarily to transfer measurements to a piece by scribing a line and to indicate the accuracy or parallelism of surfaces.

The surface gage consists of a base, the bottom of which is usually grooved to permit use on cylindrical surfaces, and an upright called a spindle to which a scriber or an indicator can be clamped. The spindle can be positioned in any angle with respect to the base and tightened into place by a spindle nut. For further fine adjustment, an adjusting screw on the base operates a rocker bracket allowing for a limited up and down movement. The scriber can be mounted either on the spindle nut where the working height is small or on the spindle for most work.

Whenever the scriber is used the surface gage is considered a non-precision measuring instrument. Usually it is used in this manner for layout work where the surface of the work is dyed and a line is scribed to the desired dimension.

Frequently the surface gage is used with a dial indicator and in this manner it is considered a precision instrument. It then can be used to compare a surface with a standard measuring device such as gage blocks or a Pla-chek height gage.

When the surface gage is used, the general procedure is to set the scriber or indicator to the approximate position desired and then with the use of the rocker adjusting screw make the final and exact adjustment.

We are indebted to Mr. J. L. Hawkinson, for permitting us to print this material on gauges. Mr. Hawkinson is the director of training in the Quality Control department of Sundstrand Aviation. His material on gauges is part of a series of articles on gauging equipment, designed to instruct the inspectors at Sundstrand.

Plastic Bag-Lift

Removal operations of an American Airlines DC-6B which had sunk through deteriorated concrete at Pueblo (Colorado) Airport, was aided by plastic bags flown from Denver Naval Air Station, reports *Aviation Week,* McGraw-Hill publication. The bags were inflated under the wings to lift the wheels from the bog.

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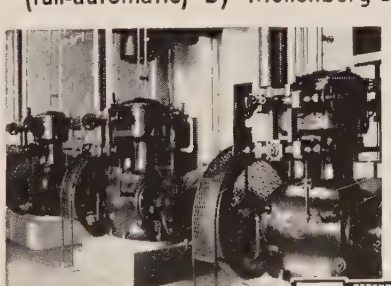

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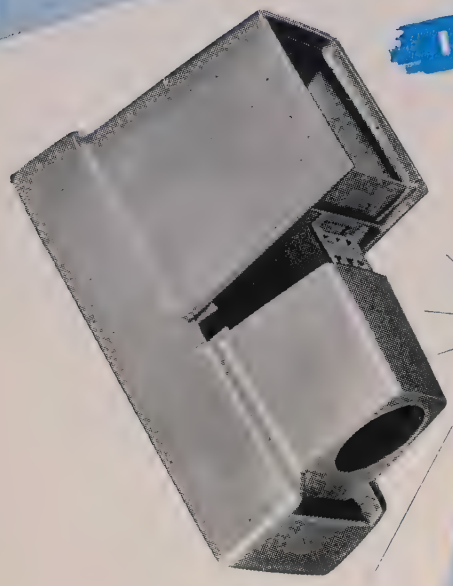

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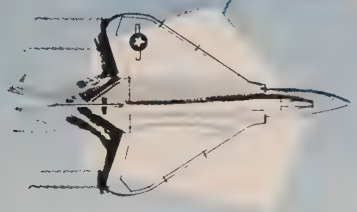

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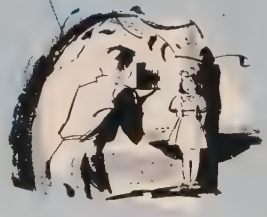

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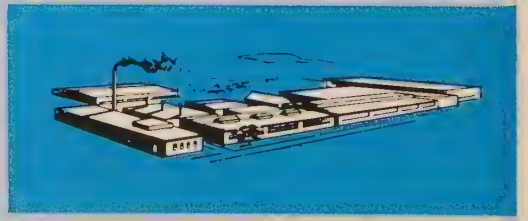

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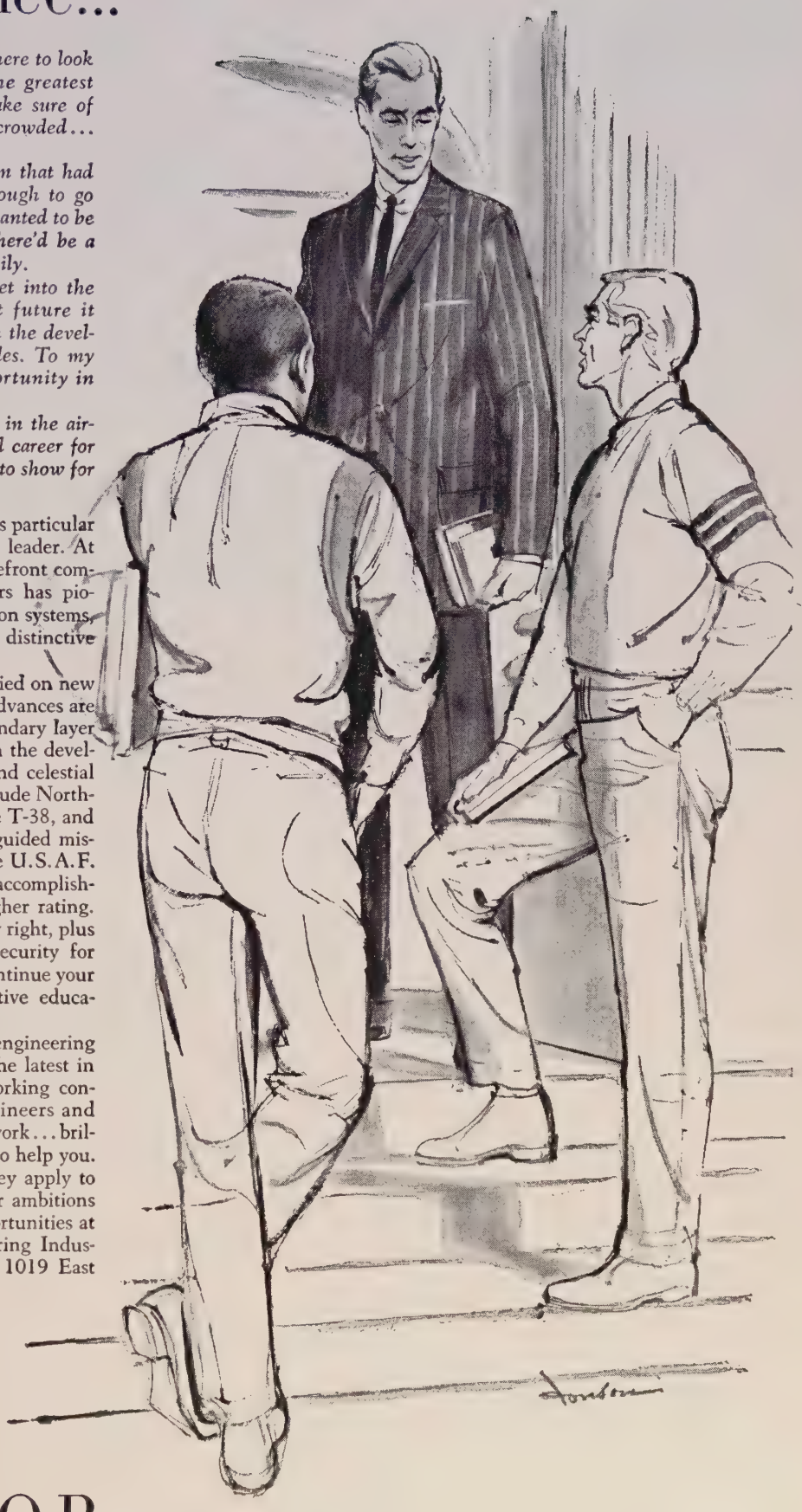

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Injecting New Life

INTO YOUR 1957 CHEVROLET

by Ralph E. Jennings, M. E. '57

Recent interest in fuel-injection has brought it from the realm of sports cars to the American family car. This article discusses the first production car usage—the 1957 Chevrolet.

In 1957 Chevrolet became the first production car in America to be equipped with fuel injection. This system along with other engine refinements has enabled Chevrolet to reach an efficiency no other production car has been able to obtain, one horsepower for every cubic inch. The refinements which helped make this efficiency possible on the 283 cubic inch engine were, increasing the compression ratio to 10.5 to 1, increasing the bore from 3.75 to 3.875, installation of a new header type exhaust system, extending spark plugs ⅛ inch deeper into cylinder (to reduce flame travel), valve and camshaft modifications and a larger more efficient intake manifold.

The decision to engineer and produce something as radically new as fuel injection is logical from a Chevrolet viewpoint, because a year ago it was common knowledge that both Ford and Plymouth were undergoing major style changes, while Chevrolet had decided only only a major face lifting. Chevrolet had no choice but to come up with something new to provide impetous for sales and fuel injection has filled this need admirably. One of the most surprising things however was the fact that Chevrolet engineers had enough confidence in this more or less unproven system to offer it as optional equipment on the entire line.

Before going into specific detail about the Chevrolet fuel injection system it might be worthwhile to list some of the advantages and disadvantages of fuel injection in general. They are:

Advantages . . .

1. Immediate response to throttle.
2. Increased power output at high speed.
3. Increased torque at low speeds.
4. Fuel flow unaffected by maneuvering (i.e., high speed turns, fast stopping or road conditions).
5. Better fuel economy through more even distribution and slightly leaner mixtures and higher volumetric efficiency.
6. Reduction of unburned fuel on deceleration.
7. More rapid starting and warmup in cold weather.
8. No carburetor icing and less tendency to vapor lock.
9. No surging and less tendency to backfire.
10. Greater tolerance in fuels used because there is less tendency to detonate.
11. Better compensation for altitude and temperature changes.

Disadvantages . . .

1. Higher initial cost.
2. Poor hot starting characteristics.
3. Noisier than carburetors.
4. Fuel system more sensitive to corrosion and dirt clogging.
5. Fewer trained personnel to maintain equipment.

Many of the advantages of fuel injection are very desirable for stock car racing (i.e., No. 1, 2, 4) and undoubtedly this entered into the thinking because the ability to win stock car races also sells cars these days.

Three Basic Types . . .

There are basically three types of fuel injection systems, timed injection, injection carburetion, and continuous flow injection.

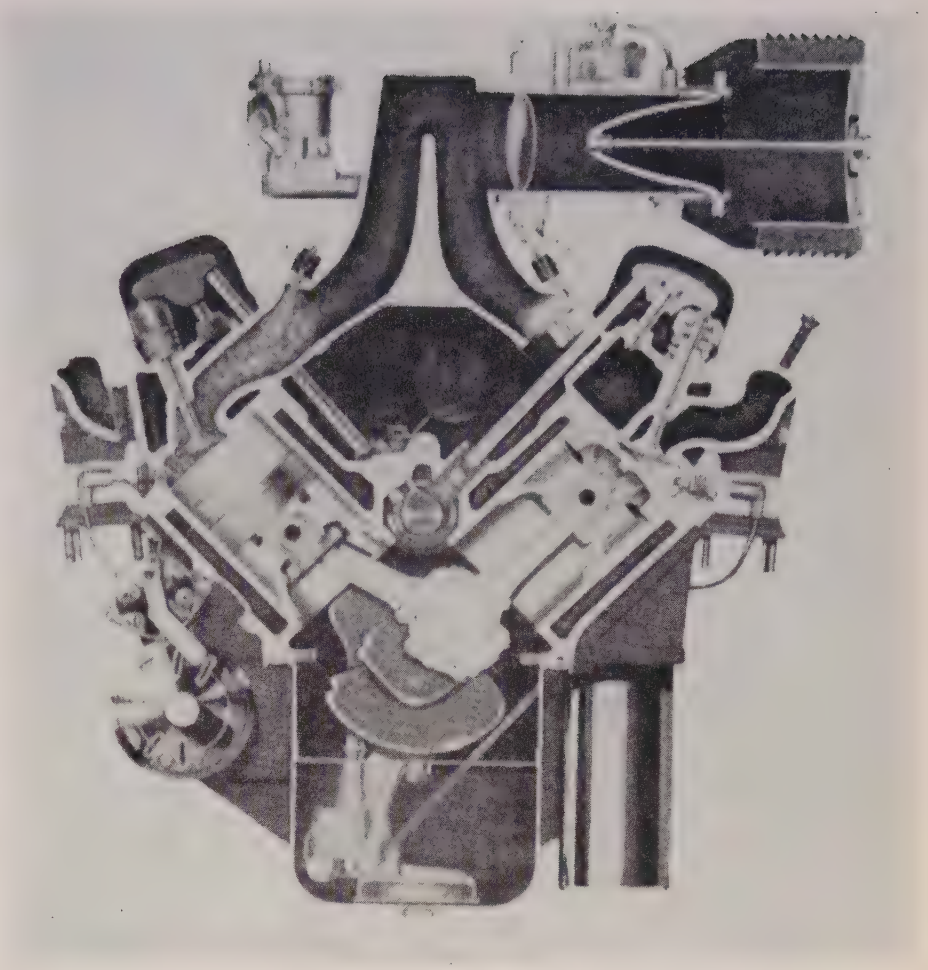
The timed fuel injection system can either inject fuel at the ports or direct into the cylinder. It is presently used on diesel engines and expensive sport cars such as the $7600 Mercedes-Benz. This type of system, when it injects fuel int othe cylinders, has a big advantage in that the charge can be injected independently of valves, which at high speeds will give the engine more charge than could be inducted through valves. Very nice and very expensive!

Injection carburetion is a system in which the fuel is injected into a manifold after the air has passed through a carburetor. This system gives complete freedom from carburetor icing and therefore it has found extensive use on aircraft power plants, but at the present very little is being done on any automotive application.

Continuous flow injection was the method chosen by Chevrolet for two obvious reasons, cost and simplicity. This type of injection has already met with success in racing. The Hilborn port injection system has been so successful in fact, that carburetors are a rarity at the "Indianapolis 500" now.

To control the fuel metering, Chevrolet developed a very fine mass flow mixture control unit with an annular bell shaped venturi. This system is so efficient that the pressure drop across the venturi is less than one pound at 6000 rpm. Add to this a thermostaltically controlled idle enrichment, a manifold controlled overrun fuel cut-off and full-throttle enrichment and you come up

Parts and layout of the Borg-Warner injection system. Pump is single-plunger distributor type, with speed-density mixture control. ⟶



with a pretty efficient, low cost metering device.

This is how the Chevrolet system is set up:

1. Fuel is pumped by a standard fuel pump from the gas tank to a float chamber.

2. From the float chamber the fuel is then pumped (by a high pressure pump, which is cable driven, from the distributor housing) to the fuel control valve.

3. The pressure within the valve chamber, which is controlled by the mixture control unit, determines the position of a spill plunger, which in turn determines how much fuel will be returned or delivered to the injectors.

4. Air from a manifold is now mixed with the fuel at the nozzles and the charge is sprayed directly into the intake ports.

Although there are many advantages to fuel injection, customers will have to wait until an engine is designed from the crankshaft up for fuel injection to really benefit from all of them. Chevrolet has done an excellent job of modifying an already established design and should benefit from some of the following points.

Why It's Good . . .

Better fuel economy through more even fuel distribution. Carburetors, because they do not distribute the charge evenly, are forced to run slightly richer than necessary to insure that no cylinder gets too lean a mixture, but injectors can be set for the correct mixture without fear of starving some cylinder.

Volumetric efficiency should be increased because now that the fuel is mechanically atomized there is no need for manifold heating devices and a colder heavier charge of air can be inducted. For the same reason there will be less tendency to detonate so that the compression ratio can be raised and the spark can be advanced further while still using present fuel octane numbers.

Improved performance on highways and stock car tracks will result mostly from the injection system being insensitive to high speed maneuvering and to its instant throttle response. Both will help in accelerating out of turns on the tracks, or in passing other cars quickly and safely on the highways.

Considering all things Chevrolet has done a fine job and has undoubtedly set the pace in efficient engine design for other automotive companies to follow.

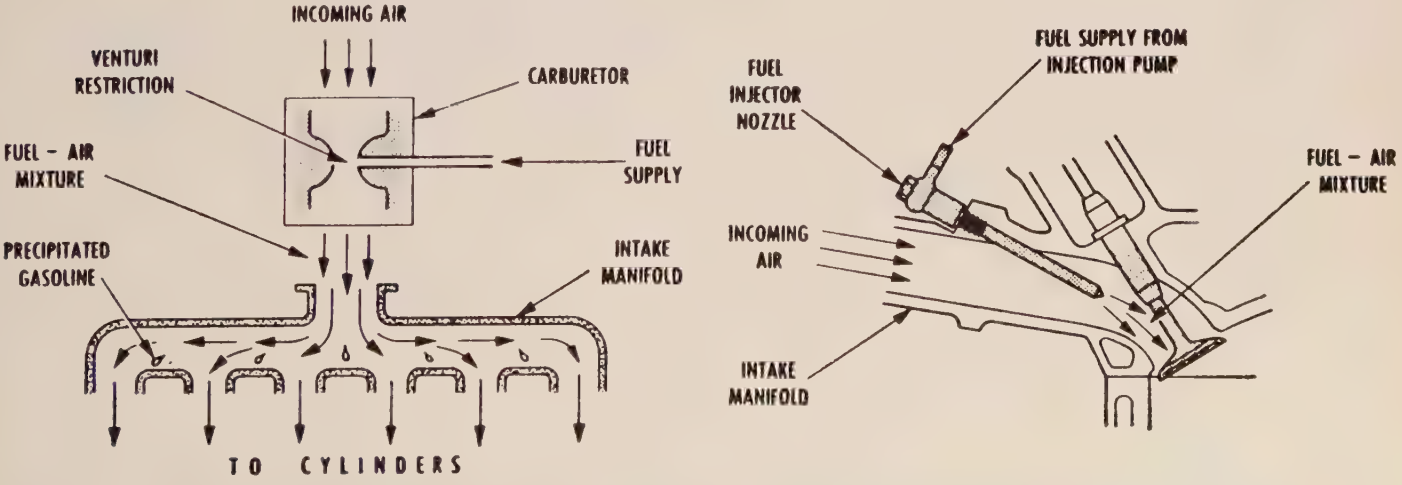


FIG. 3. WING-BODY COMBINATION AND EQUIVALENT body of revolution differences between a very crude carburation system and a fuel injection layout are shown in these two drawings, which are simplified to expose basic features of each. (Photos from Motor Life)

Arne Steivang and Charles Baumann of Federal Bakery Co., Winona, Minnesota, receive engineering service and product data from Stan Nelson (left), of Standard Oil, to help keep maintenance costs low on Federal's truck fleet.

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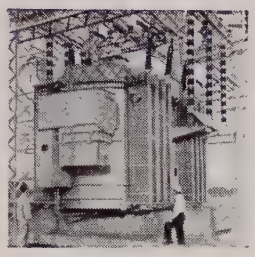
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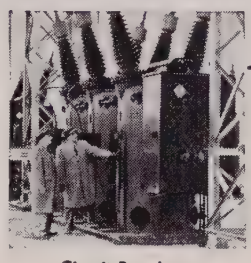
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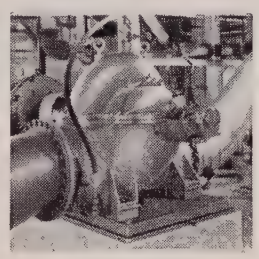
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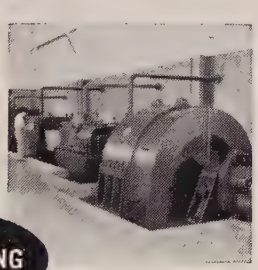
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The Big Engine That Can

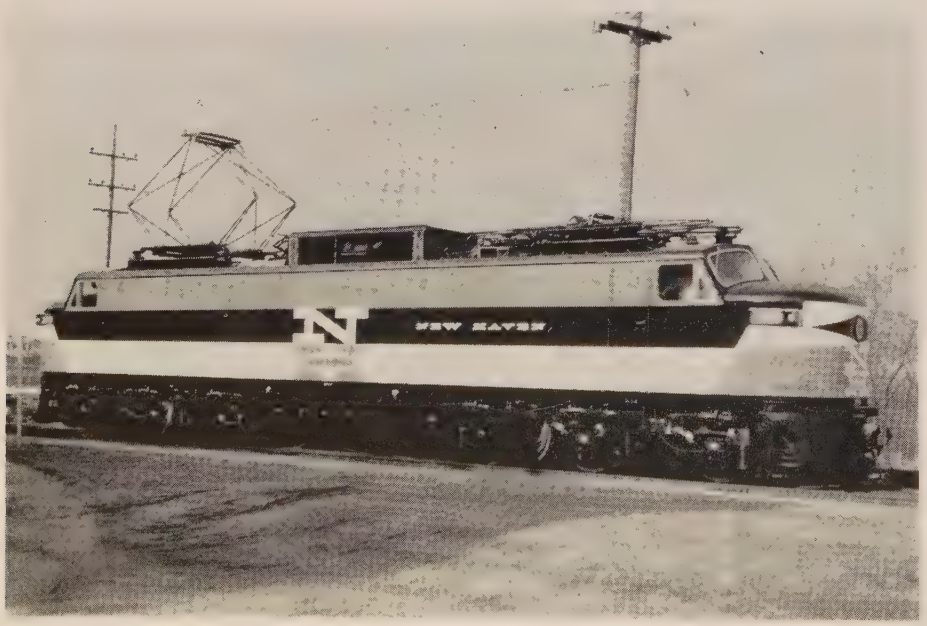
by Harry Hirsch, E. E. '57

The Rectifier cures the railroads' problem of converting AC to DC current in their electrified operations. Thus, rectifier electric locomotives become big engines that can run on AC or DC.

Most of us can be called "railfans" in one sense or another. Who has not stopped, at least once, to listen to the whistle of a far away train or watched a huge steam locomotive struggle as it pulled a long string of freight cars? We have paused to admire a brightly-painted diesel locomotive as it sped past with a string of streamlined cars bound for some distant point.

Yet a railroad is not run by sentiment, but economics. The steam locomotive, in particular, has been doomed to oblivion recently by the laws of economics. In its place has come the diesel-electric, less glamorous, but more egficient, more powerful and cheaper.

There is another form of railroad locomotion which has existed for over 50 years and has outperformed the steam and diesel locmotives in its territory: that is the straight electric drive locomotive. The electric however, has been bound by its trolley wire or third rail to locations of heavy density traffic, mountainous regions or other spots where the more conventional forms of motive power have proved inefficient. With the grawing performance record of diesels, the electric is found in isolated regions in the mountainous West, where water power is cheap and other resources expensive, and in the densely populated East, where traffic moves with almost the abundance of big-city street car lines in the rush hours. Here the high speed and great power of the electric have reached their acme in performance.



THE NEW HAVEN AND VIRGINIAN railroads have received rectifier-type electric locomotives for passenger and heavy freight service respectively.

The electric has many disadvantages. Before a railroad can install electrification, it must install power plants and substations and either string tranmission lines or law third rail to supply the power to the locomotive.

Pro and Con

It is not until these fundamentals are accomplished that the electric locomotive can be placed in operation. With diesel operation, a railroad merely buys the locomotives and converts its servicing facilities from steam to diesel operation. The diesel is more flexible, since a power plant failure puts only one locomotive out of service, whereas an electric power plant failure incapacitates the whole railroad.

The high initial costs of the electric are balanced by its high speed and high power characteristics along with its greater efficiency. Electric locomotives built 20, 30 and even 40 years ago are still performing daily. The power of an eletcric locomotive is not limited by its

motor output as in a diesel, which will fail in overload. With heavy loads an electric locomotive can almost double its output temporarily by the use of blowers which lower its resistance losses due to heat in the motors.

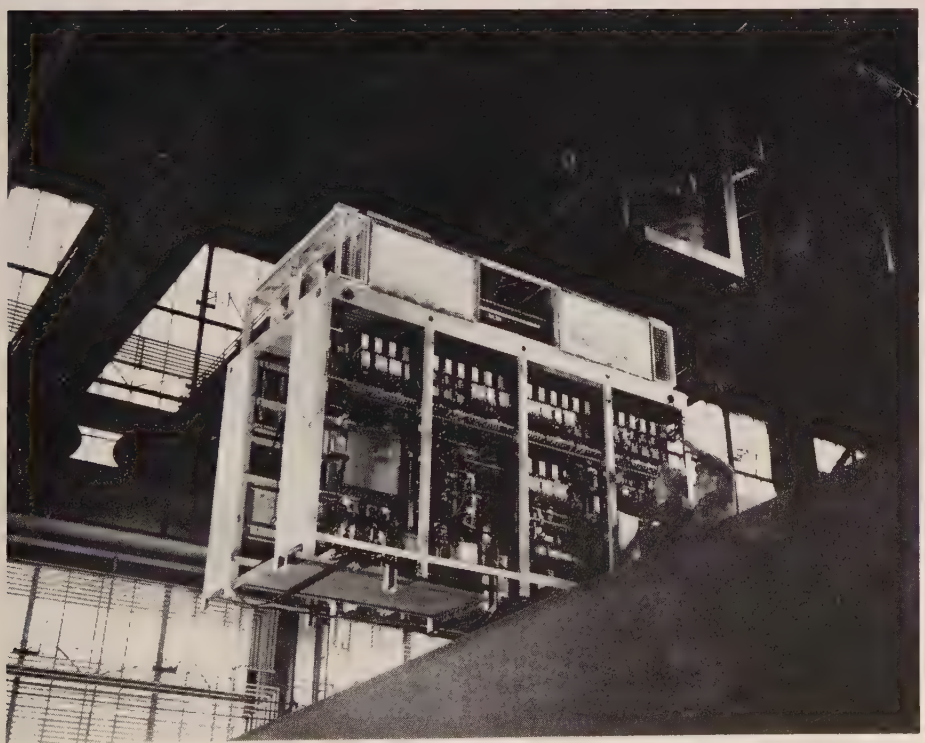
Once a railroad purchases electric locomotives it faces the problem of what type of power to use: AC or DC? AC power is suited to cheaper and easier transmission. DC power in traction motors furnish more power to the axle when in operation and are less complicated to operate. Diesel locomotives are electric motors powered by diesel fuel oil. They use DC motors to obtain low-speed, high tractive effort characteristics, which are fine for freight service.

Railroads Compromised

Some railroads employing electric power have reached a compromise in the AC or DC question. They operate AC commutator traction motors which are universal motors run on either AC or DC power to furnish DC power to the axle. Others use engine-mounted motor-generator sets which take AC power from the transmission line and change it to DC through the motor-generator set. Yet these are rather bulky and expensive to operate. Another solution is rectification of AC to DC for locomotive use.

What is rectification? Rectification is the conversion of alternating current to direct current, usually performed by devices that conduct current more readily in one direction than in other. It may be accomplished by other means as well however. A simple rectifier takes the wave form produced by AC current and accepts the peak of the wave. As the current changes direction to produce a dip, this is rejected. Thus a simple rectifier would produce a series of half waves in the same direction, with a series of gaps of no current conduction due to current reversal. If two rectifiers could be connected together so they will rectify both positive and negative portions of the cycle, the result would be unidirectional pulsating current. To achieve smooth current, this pulsating current is fed into a system of reactors or filters to smooth out the peaks and dips into a smooth unidirectional, constant current value which we call direct current.

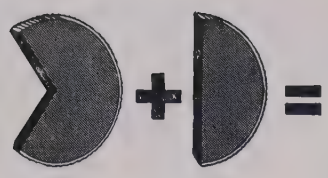
THESE STEEL COLUMNS ARE LARGE rectifier tubes to be used in the New Haven locomotives. They take 11,000 volts AC and change it to DC for traction motors on the locomotives' axles. (Photos by GE).



THE 10-TON CONTROL COMPARTMENTS which have been pre-assembled for use in New Haven Railroad rectifier electric locomotives and lowered in the completed unit contain the propulsion control equipment and accelerating resistors.

Enter the Ignition

One type of rectifier which was commonly thought applicable to railroad operations was the mercury-arc rectifier or Ignitron. A mercury arc rectifier makes use of an auxiliary starting electrode to initiate an arc at the surface of the mercury pool, from whence the arc transfers to the main anode. The Ignition is a mercury-arc rectifier with a pool-type cathode in which the arc is started by a method different in principle from that given above. The tip of the ignitor, is a rod made of semi-conductor such as boron carbide and has a relatively high electrical resistivity. It is immersed in the mercury-pool cathode. When a current of about 30 amps is passed through the ignitor to the pool by an auxiliary source of about 200 volts, a cathode spot forms at the surface of the pool. If the anode is positive at the time, an arc starts between the cathode and the anode and the tube conducts.



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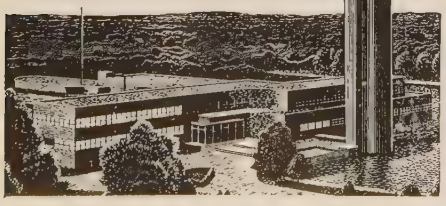


East Coast Laboratory and Microwave Tower

Ignitrons are built with single anodes to reduce likelihood of arc back, since the only unwanted conduction that can take place is that between the anode and cathode when the anode is at a negative potential. An Ignitron can be similarly arranged to accept only negative potential, while refusing positive.

While the mercury Ignitron was often proposed for railroad service, it was just as often passed off as being visionary due to the movement of a locomotive. Critics felt that the constant side-to-side motion of a locomotive at high speed would jostle the mercury from the tubes and interrupt conduction.

Several years ago, Westinghouse engineers set out to prove that the Ignitron would operate satisfactorily under such conditions and they built a special vibrating table to prove it. Several banks of tubes were placed on the table along with a glass of water. When the buffeting and jolting was over, the water was everywhere but in the glass, yet the tubes hadn't missed a cycle.

An experimental Ignitron installation was made on a Pennsylvania Railroad multiple-unit car and was judged successful after two years of steady operation.

Pennsy is First

The first use of the Ignitron in heavy duty was in two experimental freight locomotives built by the Westinghouse for the Pennsylvania Railroad. These used a bank of Ignitron tubes three feet high and nine inches in diameter. They have double walls, so that cooling water may circulate around them. The cup-shaped pool of mercury lies at the bottom, the igniter dips into the mercury and the carbon anode extends several inches down from the top. The locomotive carbody is similar to that of previous diesel electric streamlined designs. The locomotive takes 11,000 volts AC and cuts it to 830 volts in transformers and transfers it to the Ignitron tube circuits for rectification. Then the current enters filtering apparatus to smooth out the rectified current and eliminate wayside telephone interference. Controls include cinestron for motoring and braking and reversing lever. Meters include two air-brake gauges, a speedometer, an AC trolley ammeter and six DC ammeters for traction-motor current.

Service tests on the Pennsylvania have shown that the AC traction motor employed on other locmotives has a lower tractive-effort characteristic in the low-speed regions compared with DC drive, but at high speeds, the situation is reversed and the AC dirve is superior. Thus an AC drive locomotive is suitable for high-speed medium-tonnage service, while the Ignitron units are superior in low-speed, heavy-tonnage work.

The second large-scale test of Ignitrons in locomotives came two years ago when General Electric built ten passenger locomotives for the New Haven Railroad. The New Haven railroad faces a unique problem in that it encounters AC and DC transmission along its route. Part of the road extends from New Haven to Pennsylvania Station in New York City where it connects with the Pennsylvania Railroad. Both systems use 11,000 volt, 25 cycle, single phase AC. Power is taken from overhead wires through pantograph trolleys in the cab roof to the motors.

New York Problems

Another branch of the railroad enters Grand Central Station in New York City along the New York Central. The Central uses 600-volt DC, collected by metal shoes that slide on the surface of the third rail. Locomotives entering Grand Central Terminal must utilize both AC and DC. On the AC parts of the line, power is taken from the trolley and sent through the transformers and rectifier to the motors which are grouped in various series-parallel combinations.

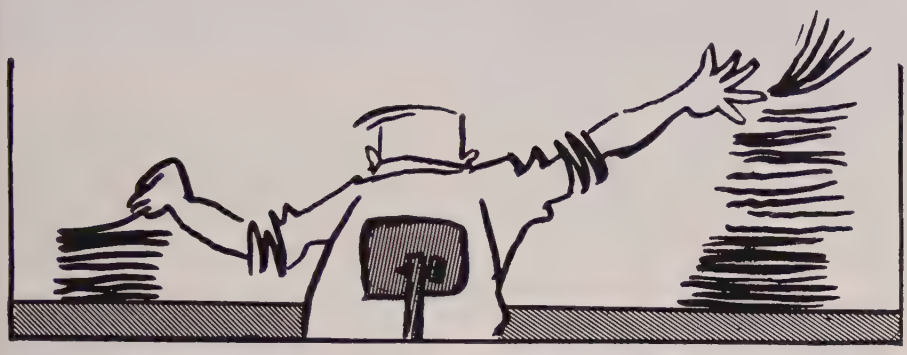
On the DC part of the line, power is picked up from shoes on each side of the motor trucks and transmitted directly to the DC motors, bypassing the transformers and rectifiers. A single switch, enables the engineer to select either AC or DC operation, depending in which zone he is running. These rectifier-type locomotives are 80,000 pounds lighter than the straight AC locomotives they have supplemented. Most of this comes from the lower total weight of the rectifier truck assembly and its lighter equipment.

Virginian Buys Locos

The most recent use of rectifier locomotives is the order of 12 road switcher electrics for use by the Virginia Railroad from General Electric. These 3,300 hp locomotives will haul heavy freight trains over 134 miles of mountainous railroad from Mullens, W. Va., to Ronaoke, Va. These locomotives use 12 electron rectifier tubes, each one foot in diameter and are geared to run at 65 mph maximum. They will have a continuous tractive effort of 79,500 pounds at 15.75 mph. They are powered by six GE 752 type DC traction motors widely used in diesel-electric locomotive service. They will take power through a pantograph trolley to collect 11,000 volt, 25-cycle, single phase AC power. The current then flows through the main transformer, through the 12 rectifier tubes and to the six traction motors.

Thus rectifier tubes may enable more railroads to electrify in their constant quest for moving more goods, faster and more economically.

Skimming Industrial Headlines



Nuclear Research

Plans for the construction of a nuclear research center in Sterling Forest, New York, were announced today by Union Carbide and Carbon Corp. The Sterling Forest region is located in the southern part of Orange County, New York, approximately 40 miles from New York City.

The major facilities on the site will include: a five megawatt pool-type reactor, a radioactive materials laboratory, an ores and engineering laboratory, and a building for allied research operations and administrative functions. It will serve as the focal point for nuclear research activity within Union Carbide. Research programs will be geared to the study of the effects of radiation on products and processes involving plastics, gases, metals, carbons, and chemicals.

Many of these programs will make use of the reactor, which is especially designed for research purposes. This reactor is a modified version of the Bulk Shield Testing Facility pioneered by Oak Ridge National Laboratory. Smaller reactors of this type have been installed on several college campuses throughout the country. The U. S. Exhibit Reactor, demonstrated to more than 60,000 people at the International "Atoms for Peace" Conference in Geneva, Switzerland in 1955, was also based on this design concept.

Adjoining the reactor building will be the radioactive materials laboratory. This building will be 138 feet long and 57 feet wide. It will contain five cells, which will enable the research staff to perform high-level experiments with radioactive materials by remote control and in complete safety.

The Ores and Engineering Building will be a brick and steel structure 146 feet long and 98 feet wide. The building has been designed to accommodate research and pilot plant operations covering the entire range of activities from mineralogy and geology to new mineral prospecting methods, including work in geophysics and geochemistry. Other work will be concerned with research on extracting metals from ore bodies.

Dog Tranquilizers

Tranquilizers to calm vicious dogs is only one result of a stepped-up research effort in veterinary medicine, reports *Chemical-Week,* McGraw-Hill publication. Also coming out of the animal-drug labs are new hormones, antibotics and vaccines.

Portable Oil Rig

A drilling rig expected to emerge from tests the most portable in its class has been delivered to the Shell Oil Co. Its designers believe that within an hour or two after the equipment arrives at a prepared site it can be readied to search for oil to depths nearly a mile-and-a-half below the surface of the earth.

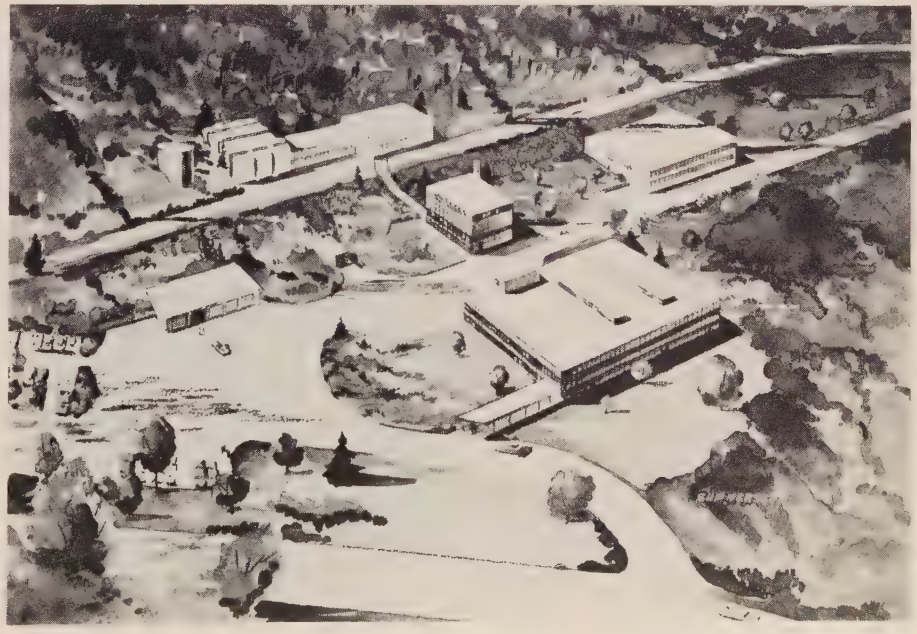
Conventional drilling rigs of similar size require a full day's work to set up.

The speed with which the new equipment can be connected and dismantled could mean it will be in actual operation the equivalent of several more weeks a year—an important advantage in the highly-competitive drilling industry.

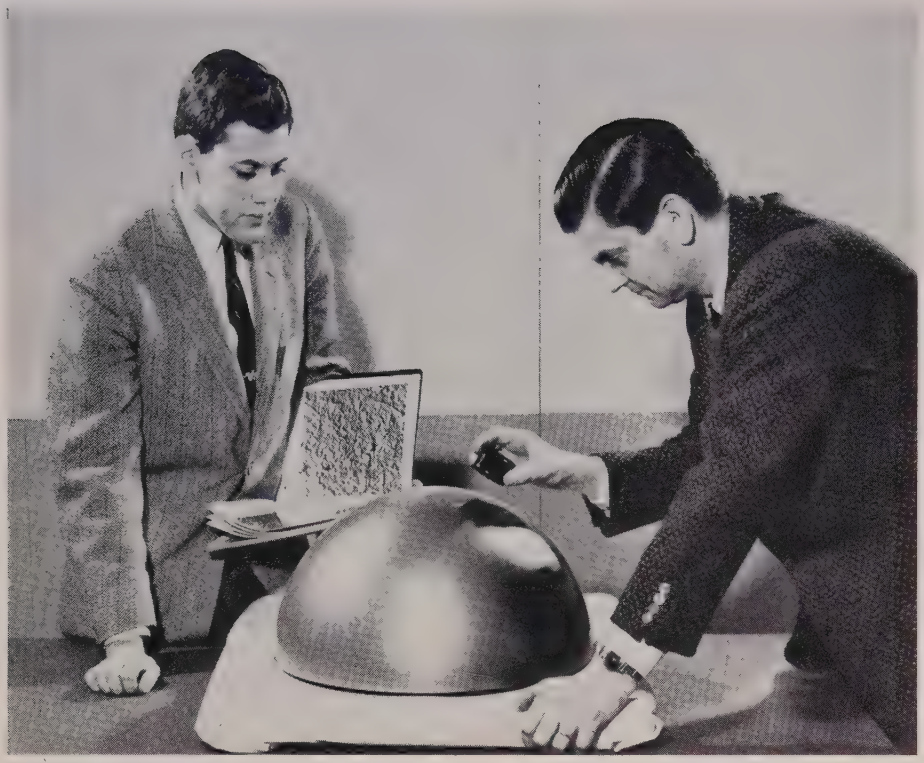
The great degree of portability is possible because the rig contains an electric drive that is relatively light in weight and is flexible in operation.

Air Suspension

At least two Ford products—possibly three—will have air suspension this year reports *American Machinist,* McGraw-Hill publication. The air-smooth ride is a sure bet for the '58 Lincoln and Thunderbird, with the "Super-Mercury" a possibility.



NEW NUCLEAR RESEARCH CENTER to be located in Sterling Forest, N. Y. It will be built by Union Carbide and Carbon Corp., and contain many advanced facilities.



ONE OF THE 19-INCH STAINLESS STEEL hemispheres superfinished by Bausch & Lomb for use as research tools in supersonic wind tunnels.

Metals Finishing

Engineers at the Bausch & Lomb Optical Co., have succeeded in producing on stainless steel hemispheres surfaces accurate to between 4 to 6 microinches (4 to 6 millionths of an inch.) They are confident that further refinements in the new process will lead to even greater precision in the near future.

Need for the super-finishing process grew out of the requirements of supersonic aircraft and missile research programs.

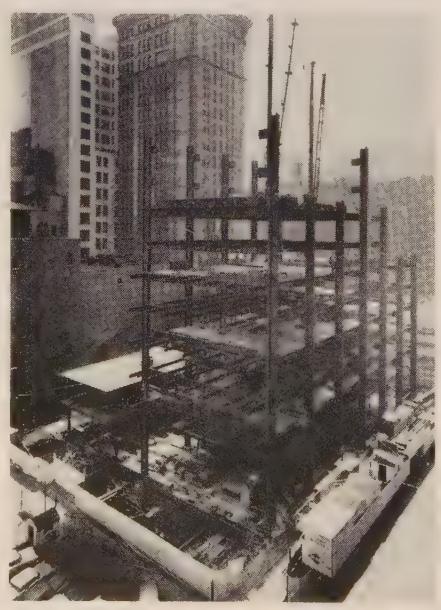
According to company officials, Bausch & Lomb has already developed techniques which permit the super-finishing of hard metals of spherical, parabolic and elliptical shapes up to 36″ in diameter. Experimentation on larger surfaces of other shapes is now underway.

Even English Complain

American utilities are not alone in getting customer complaints, reports *Electrical World*, McGraw-Hill publication. An English Electricity Board received the following letter: "I have had this property inspected, tested, checked, connected, and threatened with disconnection by so many inspectors, testors, connectors, and checkers, that it would please me to know how many actually inspected, tested, or connected, including those who arrived to inspect, test, or connect after the inspection, testing, or connecting had already been done. Gov'nur."

Inland Steel Building

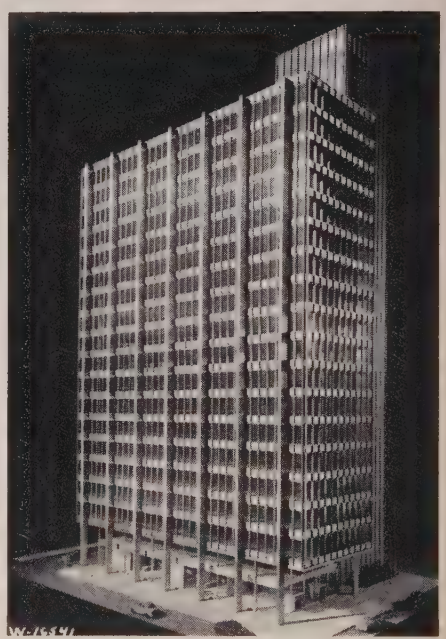
The Inland Steel Co.'s new 19-story office building being erected on Chicago's Loop district contains some striking architectural innovations and represents the first use of welded construction in Chicago's multi-story office structures. Welding proved to be the only practical way of fabricating the 4-foot deep exterior, exposed columns which permit girders 36 inches deep to span the 58-foot interior, giving a column-free unobstructed floor area.



Inland Steel Co., building during construction.

The main vertical element of the column is an 18-inch wide flange beam, positioned with the web facing outward. To the center of the outer web face and at right angles to it is welded a 1 inch standard plate, 4 feet deep. To the latter's outer edge is welded a 16-inch plate, 2 inches thick. Web stiffeners are welded to the 4-foot center plate opposite the flanges of inside tube girders. The columns will be exposed on the exterior and sheathed in stainless steel.

Shop fabrication of the columns was accomplished with multiple arc-submerged arc welding. Field joints were made in the heavy sections using a new iron powder type, low hydrogen electrode.



Inland Steel Co., when completed. (Photos by Lincoln Electric Co.)

Atomic Honeycomb

The first atomic reactor ever operated in the northeastern United States has been started up and shut down a record 10,000 times for experimental purposes.

Dr. H. B. Stewart of the Knolls Atomic Power Laboratory (KAPL) staff, said that the Preliminary Pile Assembly (PPA) at KAPL also "is believed to have produced more information about a larger variety of reactors than any other assembly." PPA has been operated successfully for eight and one-half years.

Scientists and engineers there have designed and constructed reactors for the prototype power plant for the submarine Seawolf and the actual Seawolf power plant. Currently they are designing the Submarine Advance Reactor for use in the world's largest submarine, the Triton, now under construction.

Typhoon Tractor

A new concept in farm power was unveiled when an experimental tractor, named the Typhoon, was demonstrated by Ford Motor Company's Tractor and Implement Division.

Powering the tractor is a free piston turbine engine. This marks the first known installation of this newly developed power source in a farm machine.

Merritt D. Hill, general manager of the Tractor and Implement Division, told newsmen that "we have high hopes that the experimental Typhoon tractor may be the forerunner of a totally new concept of farm power. It brings us to the threshold of power capabilities of which farmers previously could only dream. For their initial test work, the engineers have deliberately held the potential power of the Typhoon down to the useful level of 50 drawbar horsepower," he said.

Capable of running on a wide variety of hydrocarbon fuels including many agricultural products, the engine produces heated gases to drive a turbine.

Although it admittedly is years away from actual production, the free piston engine has advanced beyond the stage of a laboratory curiosity. It now is ready for exhaustive field tests and development work.

Atoms for Holland

The first shipment of nuclear reactor fuel elements made by private industry for use abroad within the framework of President Eisenhower's "Atoms for Peace" program consisted of seven elements made at the Babcock & Wilcox Company's Lynchburg, Va., nuclear facilities plant, for use in a "pool" type nuclear reactor being built for the Netherlands government. They were fabricated in the time of less than three weeks after receipt of the requisite metal, and are unique in that they are the first 20 per cent enriched uranium-aluminum alloy type elements sent abroad. The 20 per cent enrichment maximum has been set by regulation for use in foreign research reactors under the President's program.

Confusion Necessary

Physicists engaged in research for the government have learned the hard way not to order mundane objects, according to *American Machinist,* McGraw-Hill publication. Once they needed roller skates for an experiment. Auditors demanded a full report on the objects in point. For a new project, the physicists requisitioned three "ivoreen spheres." Their need: three billiard balls.

A RADICALLY DIFFERENT TYPE OF ENGINE, installed for the first time in a farm tractor is undergoing tests at the Ford proving grounds. It pulls a tow dynamometer which measures power.

Steel Curbing on Third Avenue

Steel is replacing stone on the curbings alone New York's Third Avenue, reports *Engineering News-Record,* McGraw-Hill publication. The 700 tons of steel to be used are part of the avenue's face-lifting after the removal of the elevated railway.

Oxygen Alarm

A supersensitive indicator which can measure as little as two parts per million of oxygen in hydrogen or inert gases despite the presence of up to three per cent carbon monoxide, has been developed by Baker & Co.

Producers of nitrogen, helium, and other inert gases use supersensitive oxygen indicators for quality control. Manufacturers of ammonia employ them because oxygen can poison their catalysts. Producers of liquefied-hydrogen jet fuel must guard against explosions caused by the presence of oxygen.

Manufacturers of electronic tubes and lamps, producers of synthetic fibers, metalworkers engaged in annealing, heat-treating, or galvanizing, and other users of nitrogen also must check their gas supplies for the presence of oxygen.

In Baker & Co.'s indicators, the gas being tested passes continuously over a catalyst which causes any oxygen present to combine with hydrogen. The increase in temperature caused by this reaction is measured by an extremely sensitive thermopile. The thermopile's output EMF is indicated and recorded by a potentiometer or can be fed into an automatic controller if desired.

Think Fast!

A new 8 million dollar testing device which "thinks" faster than a guided missile will be put into operation by the USAF at Holloman Air Force Base in 1958.

Known as a "real time" closed loop analysis system, it is intended to allow a single flight test to give results which now require several tests to obtain. A. W. Robinson, General Electric engineer, explained that the new technique will reduce the data from the first few minutes of a missile's flight and compare it with the estimated performance of the missile. On the basis of this comparison, it will be possible to select new settings and variables and transmit new instructions to the missile still in flight.

By using two high speed "Univac" computers and careful planning before flight, it will be possible to do in half a second what is usually done between flights. This will allow much greater use of each missile in the development program and result in a considerable saving in time and money. Under the new testing technique, one missile will do the work of several because electronic brains can now "think" faster than the missile flies.

Success Measure

When it comes to salaries, people tend to be alike, says *Factory Management and Maintenance,* McGraw-Hill publication. One job evaluation experts puts it: "People want to know 'how much am I getting, but how much is the guy next to me getting.'"

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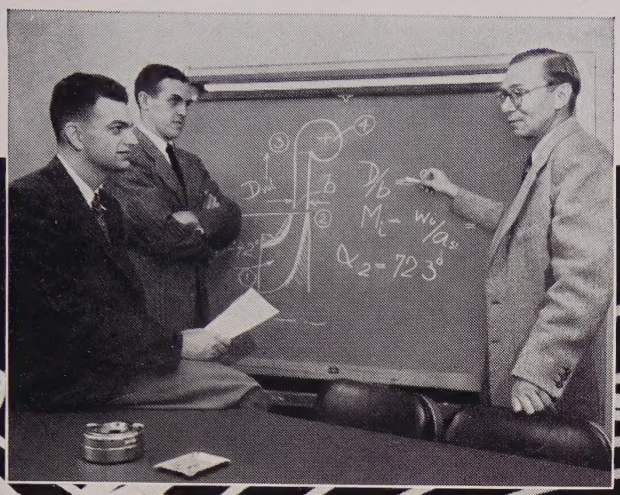
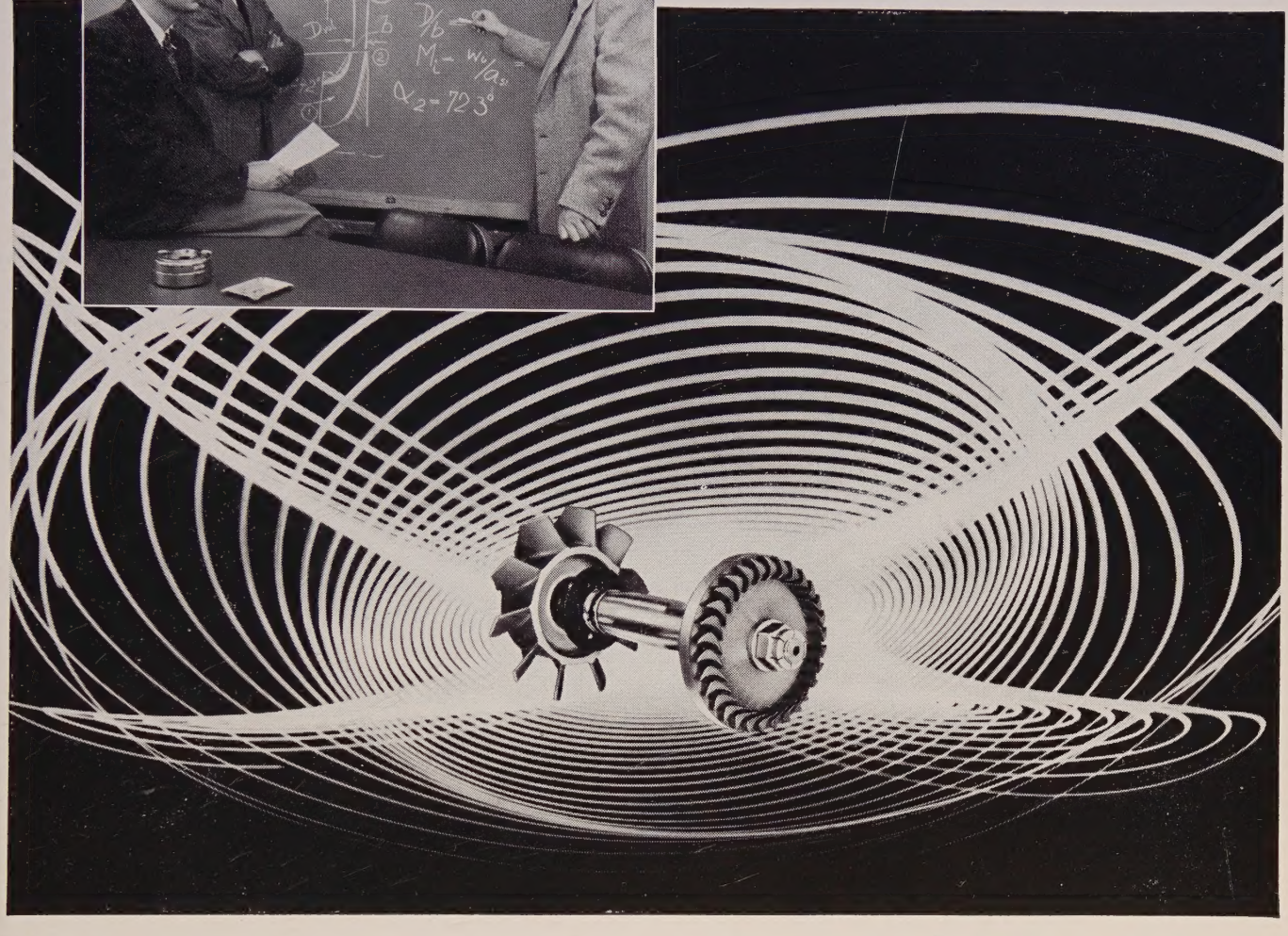


Six inch long compressor-turbine assembly in a midget AiResearch air expansion refrigeration unit which operates at 100,000 r.p.m., can drop temperature more than 600° F. in a second.



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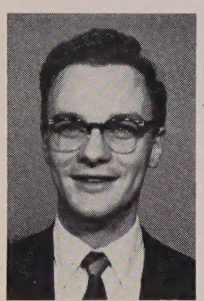
TECHNOCLIPS

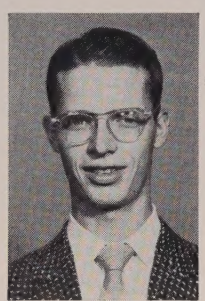
New Editors

This being the seventh and next-to-the-last issue of this year of *Technograph,* we have been busy preparing our staff for next year and looking over editor prospects. This may seem a little early to readers, but we feel it better to select our editors for the coming year before the last issue so they can spend the last issue "breaking-in" to the job, while the older, more seasoned editors are around to give fatherly advice.

Next year's editor will be Jim Kries, Eng. Physics, '59. Jim is a first semester junior and has worked on the staff



JIM KRIES



ROGER HARRISON

PHIL PHILHOWER

for two years. He was associate editor this year and has written "IBM Cards" in our March issue; "Physics Research," in February; and "National Bureau of Standards" in December.

He is a veteran, having served four years in the Army and a native of Chicago.

Roger Harrison, E. E., '59, will be business manager. Rog has been associate business manager this semester, picking up the tricks of his trade. While he hasn't been engaged in counting money, Rog wrote the article on Transistors in our October issue. He has been on the staff for two years.

Phil Philhower, Aero. E., '60, returns as circulation manager for another year. Phil has been the man who has supervised subscription sales, newsstand sales and checked our mailing list every month. He hasn't had a nervous breakdown yet, so he's back for more next year.

Good luck men.

Yeah—We Goofed

From the first day that our March issue appeared on the news-stands, we have been hearing wisecracks as to how we goofed on our cover illustration and cover story. As if we didn't know! We had requested a plate from Union Carbide & Carbon Corp., the plate which adorns our cover this month. Unfortunately there was a mix-up as to sizes and then the plate got lost somewhere in transit. We were faced with a magazine which was printed and ready for binding except for a cover. So rather than hold up the works any longer, we substituted a plate of the entrance to Civil Engineering Hall. But due to the fact that the text of the magazine was printed, we couldn't correct our plate identification. Sorry. But matters have been rectified this month. Cover plate and cover story match (we hope).

Revised Engineering Vocabulary—Draftsman's Version

Chief Engineer—An overpaid individual who can never do his job 50 per cent as well as the person criticizing him could, if given the chance.

Estimator—An underworked character with a perverted sense of humor and a grudge against the world who takes great personal satisfaction in allowing only 10 per cent of the time required to do any job.

Engineer—A mechanical genius who refuses to recognize his own ideas when confronted with them on paper.

Draftsman—An imposed-upon person who is expected to translate the brainstorms of the engineer into something practical and workable.

Engineering Secretary—An Angel on Earth who can translate the gibberish dictated by the engineers into a letter sure to impress the one that receives it with the knowledge of the sender.

Application Engineers and Sales Department—A group of fast talkers who will promise anything, disregarding the fact that even God took six days to create the heavens and earth.

Planning Department—A small group of extroverts who live by the motto, "This job is going too easy; let's complicate it."

Blue Print Boy—A youthful male so wrapped up in dreams of tonight's date and memories of last night's date that he can seldom be prevailed upon to make a print.

Checker—An erratic individual with a red pencil and no conscience who feels obligated to change anything anyone else puts on a drawing.

Technograph Census

Just for kicks the other day we examined our masthead and counted 24 names. For some reason, over half of our staffers are EEs. In the latest College of Engineering tabulations, EEs account for only 1/3 of the heads on North Campus. Who can account for this? Do EEs have more spare time to devote to activities than their brother engineers? Are they more verbal? Are they more articulate? We have a couple of non-engineers also with Phil Hicks, Pre-med '58 on our editorial and circulation staffs and Arlene Hornick, LAS '58, make-up editor. Phil, however, was formerly in engineering physics (or was it biological chemistry) before his switch to pre-med. Arlene hopes to enter the field of journalism and is utilizing *Technograph* as a means of gaining experience in magazine make-up.

These two in particular, reflect *Technograph's* editorial stand. That is, anyone is eligible to join who is interested in magazine work of a technical nature. Our stories are written for engineers and people interested in technical subjects, but not limited to engineers alone. We welcome anyone who can contribute. Stories of technical subjects, such as research projects, biographical items on faculty members or great scientists, or short stories that would appeal to technical readers are all acceptable. Other staff openings are for photographers, artists for cover illustrations and cartoons as well as illustrative drawings and charts, circulation workers to keep our news-stands stocked with *Technographs* and our subscribers happy; office workers to answer mail, type articles and keep the place in order. And remember girls, the ratio of men to women on the *Technograph* staff is 12 to 1!